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ABSTRACT

Developed by the ABCs of Construction National Workplace Literacy Project, these seven workbooks are designed to enhance the basic skills of pipefitters. Reading and Solving Basic Pipefitting Problems #1 defines and uses eight basic terms pipefitters need to know, reviews steps a pipefitter must take to identify and solve a simple pipefitting problem, and includes simple problems to find "take out" and welder's gaps. Reading and Solving Basic Pipefitting Problems #2 reviews seven basic terms pipefitters need to know, uses each term while solving 45 pipefitting problems, introduces a five-step method to solve pipefitting problems, and provides practice exercises. Practicing Problem Solving for Pipefitters uses pipes velcroed onto a wall to practice real pipefitter problems, using the five-step method. Exercises are designed to help the worker transfer the method to handling a real-world pipefitting problem. Basic Vocabulary for Pipefitters depicts and explains 11 terms and has a fill-in-the-blanks exercise. Basic Trig for Pipefitters explains right angles, teaches the worker how to "see" one in pipe elbows, reviews what the sides of a triangle are called, practices how to see them in a pipe elbow, shows the worker how to use a trigonometry chart to find tangents, and includes practice exercises. Reading and Solving Pipefitter Take Out Problems shows what a "take out" is, provides exercises on finding one, shows how to read "The Pipefitters Blue Book" to find tangents, and provides practice exercises. Reading and Solving Basic Pipefitting Problems # 3 introduces four steps to solve simple offset problems when the elbows are not 45 or 90 degrees and provides simple offset examples and problems. (YLB)

Pipefitter Workbooks

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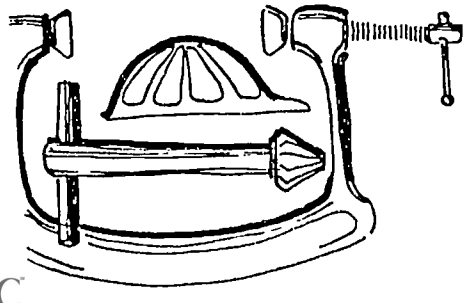
TECHNICAL DEVELOPMENT CENTER

Reading & Solving
Basic Pipefitting Problems # 1



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Instructor Information for the Pipefitter Series

Seven workbooks have been designed to enhance the basic skills of pipefitters at the Technical Development Center. A brief description of each workbook follows:

1. Reading and Solving Basic Pipefitting Problems # 1
   Defines and uses eight basic terms pipefitters need to know. Reviews steps a Pipefitter must take to identify and solve a simple 90 pipefitting problem. Includes simple problems to find "take out" and welder's gaps.

2. Reading and Solving Basic Pipefitting Problems # 2
   Reviews seven basic terms pipefitters need to know: "center line," "cut length," "face to face," offset," "run," "take out," and "welder's gap." Uses each of these terms while solving 45 pipefitting problems. Introduces a five step method to solve pipefitting problems. Provides exercises to practice this five step method.

3. Practicing Problem Solving for Pipefitters
   Uses the pipes velcroed onto the movable wall in the TDC room to practice real pipefitter problems. Workers use the five step method introduced in Reading and Solving Basic Pipefitting Problems # 2 to find the "cut length" of the connecting pipe between pipes located on the movable wall. Exercises are designed to help the worker transfer the five step method to "handling" a physically real pipefitting problem.

4. Basic Vocabulary for Pipefitters
   Depicts and explains eleven terms pipefitters need to know. Has an exercise wherein the worker must fill in the blanks using the correct terms.

5. Basic Trig for Pipefitters
   Helps the worker to know what is a right triangle and to be able to "see" right triangles in pipe elbows. Reviews what the sides of a triangle are called: "hypotenuse," "adjacent" and "opposite." Practices how to "see" these sides in a pipe elbow. Shows the worker how to use a trigonometry chart to find the tangent of an angle. Includes exercises for to find "take outs" wherein the worker must use a trig chart to find the tangent of an angle.

6. Reading and Solving Pipefitter Take Out Problems
   Shows what a "take out" is in 90 and 45 elbows. Provides exercises to find "take outs" in 90 elbows. Reviews how to find a "take out" in a 45 elbow using a trigonometry chart to find the tangent of an angle. Provides practice exercises. Shows how to read The Pipe Fitters Blue Book to find the tangent of an angle then provides practice exercises.

7. Reading and Solving Basic Pipefitting Problems # 3
   Introduces four steps to take in order to solve simple offset problems when the elbows are not 45 or 90. Provides simple offset examples and problems.

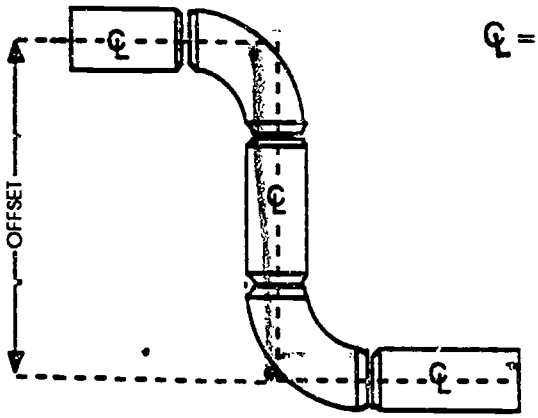
Connecting Pipes

Connecting pipes together isn't easy unless you know how to do it correctly. There are terms you need to know before we begin to review the steps you should follow in order to connect two runs of pipes together.

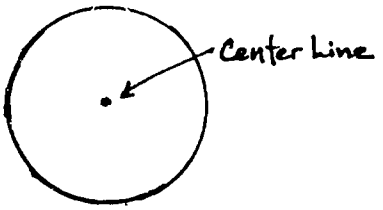
Terms Pipefitters Should Know

When you are connecting two pipes that are level with the ground, it is called a **simple offset.** Most pipes in the industrial plants are laid in north/south or east/west directions. In order to find the distance between the two pipes you want to connect, you must find the distance between their **center lines**. A center line goes along the very middle of a pipe. A center line in a pipe is like the point where someone would first place a knife in order to cut out a piece of pie. The distance between the center lines is called an **offset**.

ex.



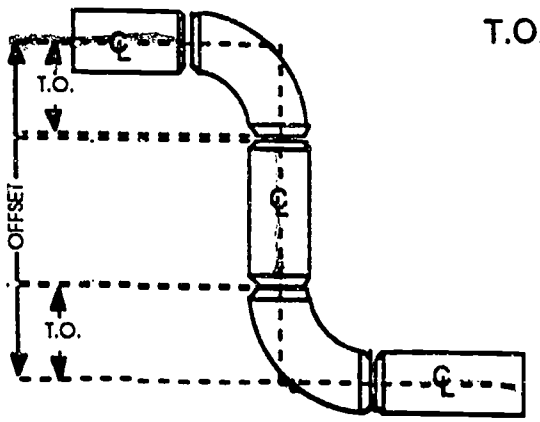
℄ = Center Line



Take Outs

In order to know how long a pipe fitting you need to connect two other pipes, you must first find out how much length the elbows (ells) add to connecting these pipes together. **Take Out** of a pipe fitting is the distance that a fitting extends the center line of a run of pipe past the end of the pipe. It is the length of pipe the elbows add to the pipe offset.

ex.

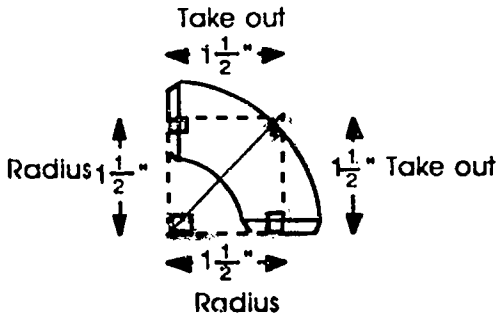


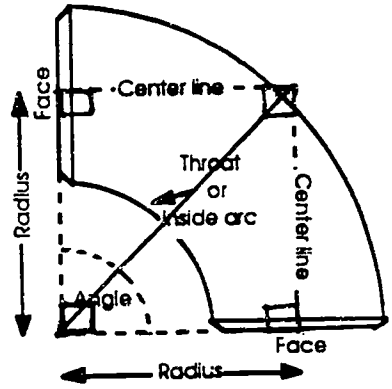
T.O. = Take Out

1

In every elbow (ell) you can "see" right triangles. The "legs" of the right triangle are actually the adjacent sides of the right triangle. In an ell they are equal to the radius of the ell and extend to the center lines of the ell.

ex.

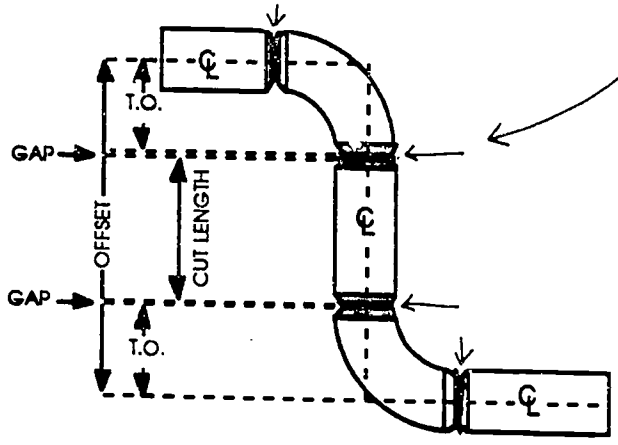




Welder's Gaps

When two pieces of pipe need to be welded together there needs to be a space allotted for the welder to make his/her weld. This space is called the gap. It is important that the pipefitter ask the welder how much space should be allotted for gaps. Depending on the size of the pipe, most welders like a ⅛" or 3/32" gap between pipes.

ex.

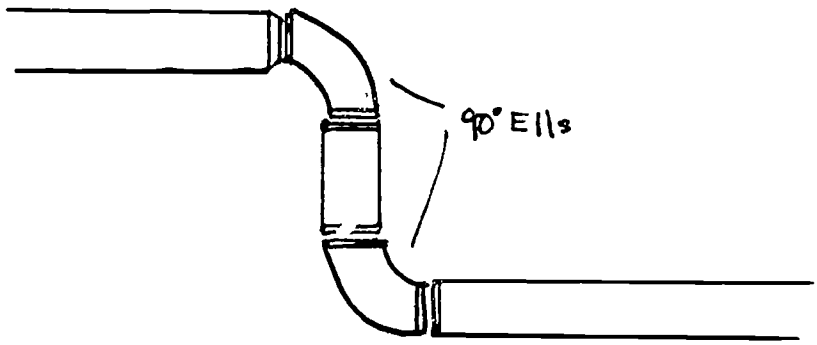


Steps to Connect Runs of Pipe

A. Identify Problem

Begin by drawing a rough picture of the pipes you need to connect and the pieces you'll need to connect them. Will the elbows[1] you use to connect these pipes use 90° or 45° elbows (ells)?

ex.

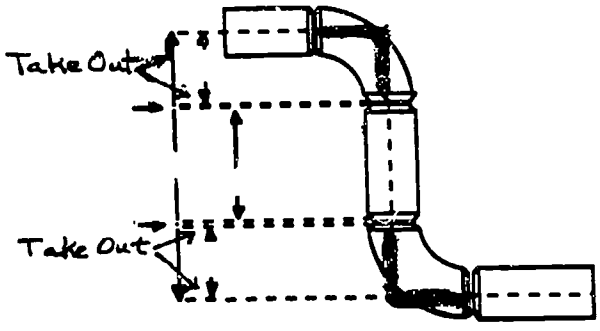


B. Find Take Outs

In order to find the length of pipe needed to connect two pipes, we must first identify how much of the offset is taken up by the ells. The center radius of an elbow that will be welded to connect two pipes together is equal to 1½ times the nominal pipe size.[2]

ex. pipe size = 6"

radius of a 6" 90°elbow = 6" x 1½ = 9"



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[1]Ell is the shortened name for elbow.

[2]Nominal pipe size (NPS) is the size we call the pipe, not to be confused with the actual size of the pipe.

Take Out Exercises

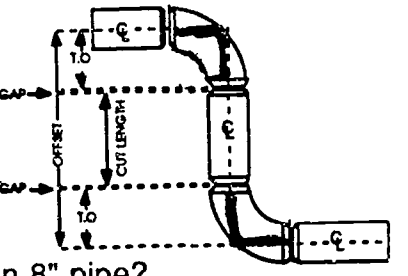
1. When using a 90° butt weld ell, if the pipe size is 8", what is the take out? (Remember, the **Take Out** of a fitting is the distance that a fitting extends the center line of a run of pipe past the end of the pipe.)

   ex. Nominal Pipe Size = 8"

   Radius of an 8" pipe = 1½ x 8"

   If radius = take out

   What is take out of a 90° butt weld of an 8" pipe?



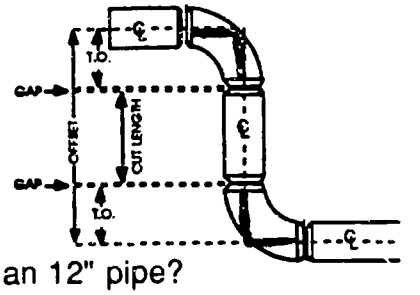
2. When using a 90° butt weld ell, if the pipe size is 12", what is the take out?

   ex. Nominal Pipe Size = 12"

   Radius of an 12" pipe = 1½ x 12"

   If radius = take out

   What is take out of a 90° butt weld of an 12" pipe?



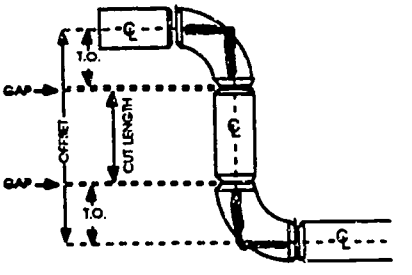
Please Note: Elbows that are factory made often have different sizes of ells than field cut ones. Be sure to check what is the actual radius of the butt weld ell you are using. If you do not check this, an incorrect radius may make your take out incorrect.

3. In a 90° butt weld ell, what is the take out if you have a factory made 5" pipe?

   ex. Nominal Pipe Size = 5"

   Radius =

   Take Out =

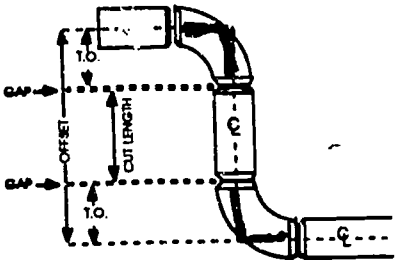


4. In a 90° butt weld ell, what is the take out if you make[3] a 3" pipe?

   Ex. Pipe Size = 3"

   Radius =

   Take Out =



[3]When you make an elbow it is called a "field cut" elbow.

Take Out Exercises

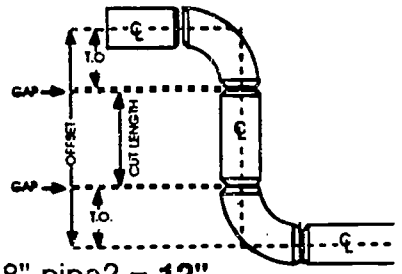
1. When using a 90° butt weld ell, if the pipe size is 8", what is the take out? (Remember, the **Take Out** of a fitting is the distance that a fitting extends the center line of a run of pipe past the end of the pipe.)

   ex. Nominal Pipe Size = 8"

   Radius of an 8" pipe = 1½ x 8" = **12"**

   If radius = take out

   What is take out of a 90° butt weld of an 8" pipe? = **12"**



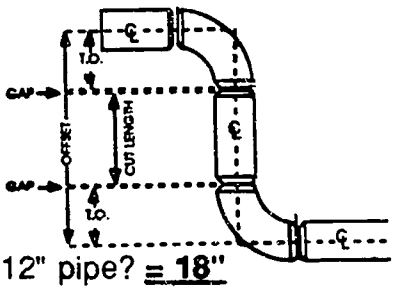
2. When using a 90° butt weld ell, if the pipe size is 12", what is the take out?

   ex. Nominal Pipe Size = 12"

   Radius of an 12" pipe = 1½ x 12" = **18"**

   If radius = take out

   What is take out of a 90° butt weld of an 12" pipe? = **18"**



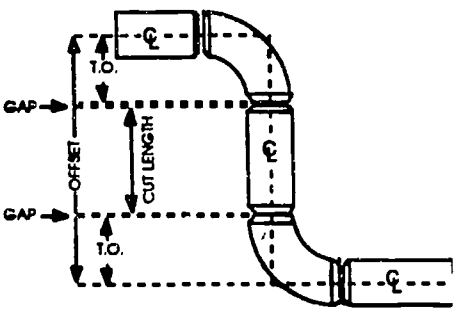
Please Note: Elbows that are factory made often have different sizes of ells than field cut ones. Be sure to check what is the actual radius of the butt weld ell you are using. If you do not check this, an incorrect radius may make your take out incorrect.

3. In a 90° butt weld ell, what is the take out if you have a factory made 5" pipe?

   ex. Nominal Pipe Size = 5"

   Radius = **1½ x 5" = 7½"**

   Take Out = **Radius = 7½"**

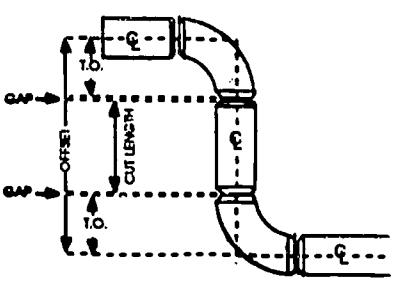


4. In a 90° butt weld ell, what is the take out if you field cut a 3" pipe?

   Ex. Pipe Size = 3"

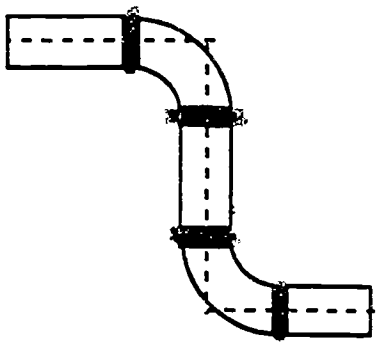
   Radius = **1½ x 3" = 4½"**

   Take Out = **Radius = 4½"**



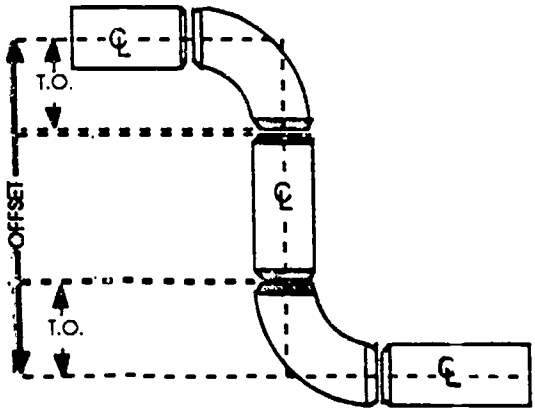
C. Find Welder's Gap

1. In connecting the pipe runs in the example below, how many welds would a welder need to make?



2. How much distance does a welder generally need to make a good weld in each welder's gap?

3. How much distance will the welder's gaps add to the length of the offset (distance between the center lines of the two runs of pipe) that are connected with 45° ells?



Answers to Welder's Gap:
1. 4 welds
2. Welds are ⅛" (sometimes welders request 3/32")
3. 2 welds and each weld is ⅛" or 2 x ⅛" = 2/8" or ¼"

Practice Problems for 90° Simple Offset

To calculate how long a connecting cut length of pipe is needed to join two pipes in a 90° simple offset, you would subtract the take outs of two 90° elbows, and two welder's gaps from the length of the run[4]. Your answer would be how long the connecting pipe should be.

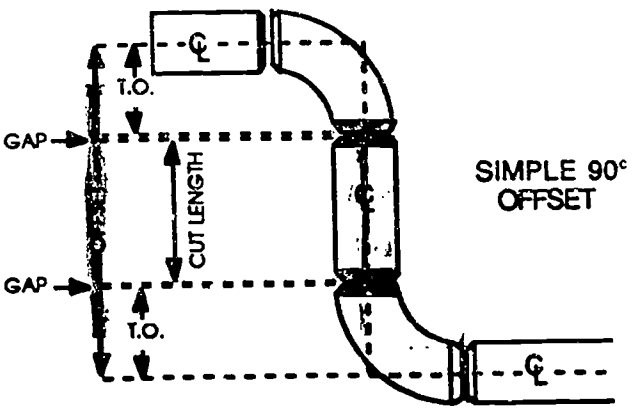
ex. Offset - 2 Take Outs - 2 Welder's Gaps = Cut Length of Pipe

5½" - 2(1½") - 2(⅛") = Cut Length of Pipe

5½" - 3" - ¼" = Cut Length of Pipe

= 2¼"

Please note: When you are determining the length of an "offset" between two pipes, you figure the run as the distance between the two center lines of the connecting pipes; therefore, your calculations include 2 welder's gaps, not all four the welder must make to complete the job.

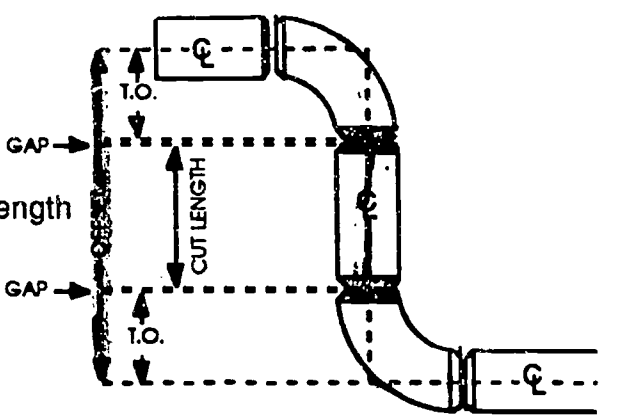


Practice 90° Simple Offset Problems

Find the cut length of the 90° offsets. Use a ⅛" for the welder's gaps (and remember there will be two of these) and that the take out for a 90°elbow is 1.5 times the NPS (Nominal Pipe Size, what it is called). Answers to these problems are found in the next section. All the steps to doing these problems are explained there.

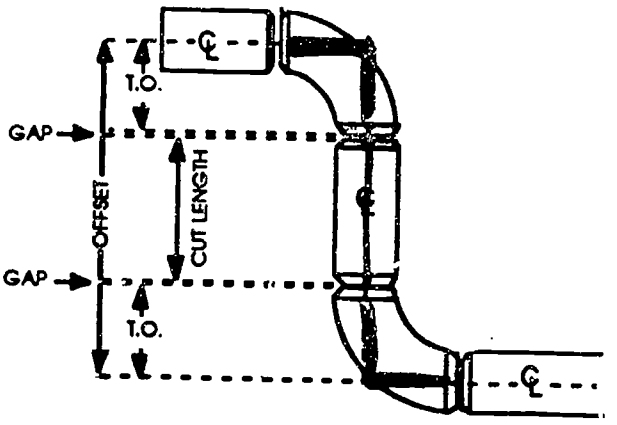
1. Offset is 24"
   Pipe size is 6"
   Cut Length of Pipe = ?

24" - 2(Take Outs) - 2(Welder's Gap) = Cut Length

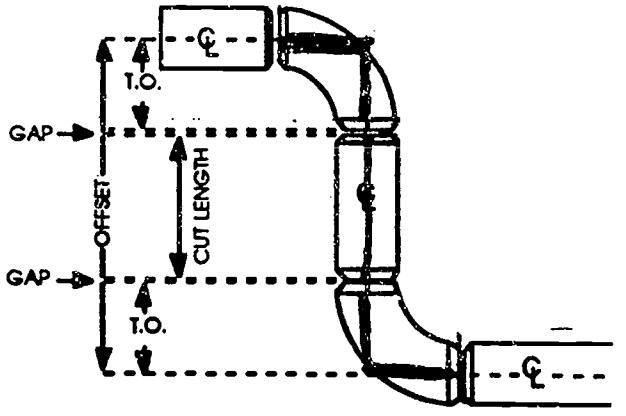


[4]The run is the path that the pipe takes to get to the new center line.

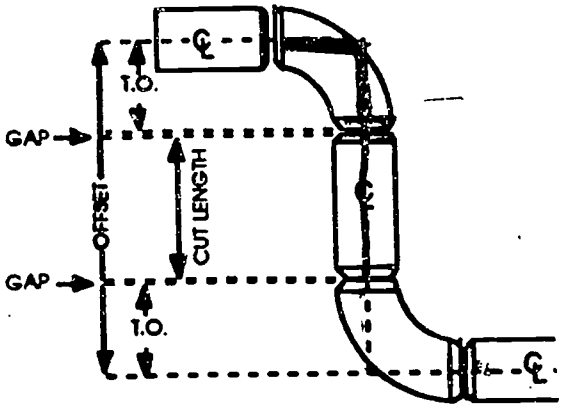
2. Offset is 6'2½"
Pipe size is 2"
Connecting pipe length is = ?



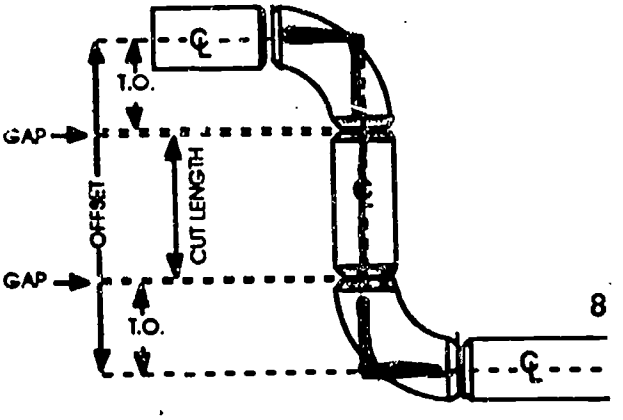
3. Offset is 17"
Pipe size is 3"
Connecting pipe length is = ?



4. Offset is 19'11"
Pipe size is 8"
Connecting pipe length is = ?



5. Offset is 22'4½"
Pipe size is 12"
Connecting pipe length is = ?



Answers:

1. Offset is 24"
   Pipe size is 6"
   Connecting pipe length = ?

   24" - 2(Take Outs) - 2(Welder's Gap) = Length of Connecting Pipe
   24" - 2(6" x 1½) - 2(⅛") = Length
   24" - 2(9") - ¼" = Length
   24" - 18" -¼" = Length
   = 5¾"

2. Offset is 6'2"
   Pipe size is 2"
   Connecting pipe length is = ?

   6'2" - 2(2" x 1½) - 2(⅛") = Length
   6'10" - 2(3") - ¼" = Length
   6'10" - 6" -¼" = Length
   = 6'3¾"

3. Offset is 17"
   Pipe size is 3"
   Connecting pipe length is = ?

   17" - 2(3" x 1½) - 2(⅛") = Length
   17" - 2(4½") - ¼" = Length
   17" - 9" -¼" = Length
   = 7¾"

4. Offset is 19'11"
   Pipe size is 8"
   Connecting pipe length is = ?

   19'11" - 2(8" x 1½) - 2(⅛") = Length
   19'11" - 2(12") - ¼" = Length
   19'11" - 24" -¼" = Length
   = 17'10¾"

5. Offset is 22'4½"
   Pipe size is 12"
   Connecting pipe length is = ?

   22'4½" - 2(12" x 1½) - 2(⅛") = Length
   22'4½" - 2(18") - ¼" = Length
   22'4½"[5] - 36" -¼" = Length
   = 19'4¼"

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[5] 22'4½" = 19' + 36" + 4½"
(3' = 36")

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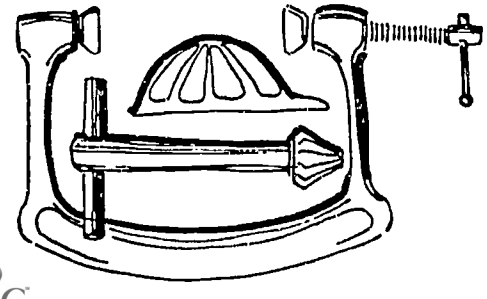
Reading & Solving Basic Pipefitting Problems # 2



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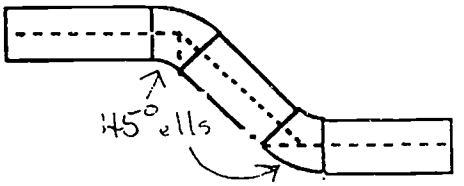
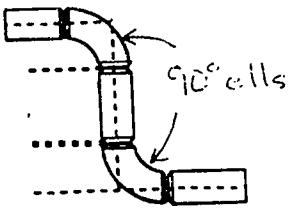
Basic Pipefitting # 2

Connecting pipes that are fairly close together may require the use of 45° butt weld elbows. Many electricians would like to use an 45° elbow because it is easier to pull their wires through it than the 90° elbow. In the petrochemical industrial plants, 45° elbows are most often used to connect pipes because liquids or gases can flow more easily through them.

The 45° butt weld elbow is the second most used butt weld (B.W.) elbow.



The most common kind is the 90° elbow (ell).



The words you should know to do the problems that follow are:

Run The path that a pipe takes to get from one center line to another center line.

Offset Usually a combination of two ells and a cut length of pipe that moves a line of pipe to a new position.

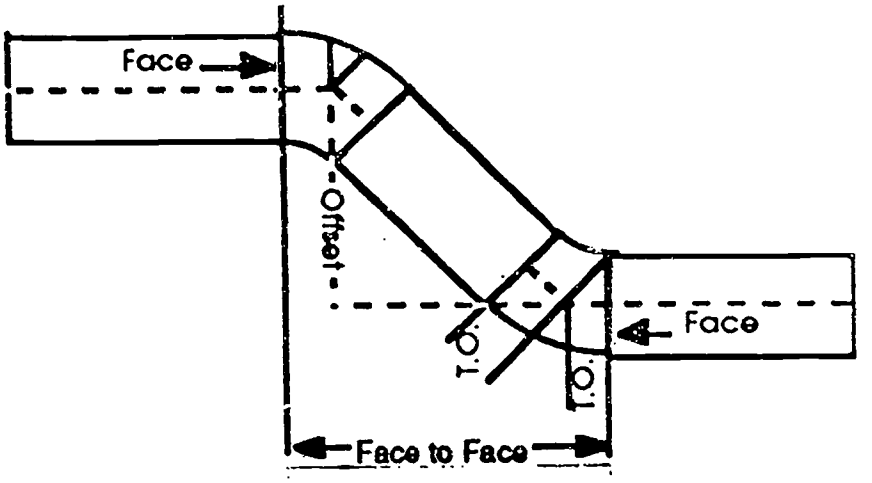
Center Line The line that is equal distant from all sides of a pipe that is in the middle of a pipe.

Take Out The distance that an ell extends the center line of a run of pipe past the end of the pipe.

Welder's Gap The space between a fitting and the pipe that is filled by welding.

There is another term you need to know when you work with 45° Butt Weld ells.

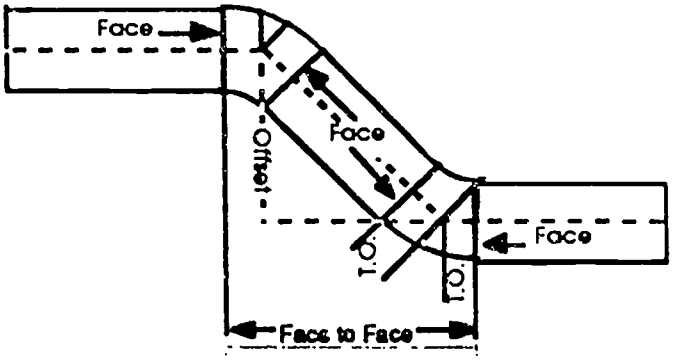
Face to face The distance between the parallel faces of the pipes you are trying to connect.



When you measure the distance between two pipes you'd like to connect, there are five steps you can follow in order to find out how long you should cut the length of the pipe to connect those pipes together.

Step 1 **Measure the distance between the two pipes. This distance is the "face to face" distance between the two pipes to be connected.**

a. Measure how far the two pipes are apart. Be sure if you measure the distance from the bottom of one pipe, you measure to the bottom of the other pipe (or the top to the top).



Step 2 **Find the "take out"** (the distance an ell extends the center line of a run of pipe past the end of a pipe).

a. Identify the size of the pipes you will connect together (is it 3", 6", etc.).

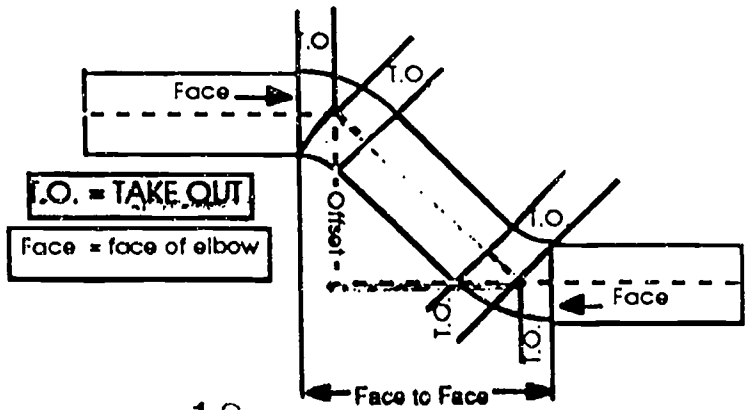
b. Identify if the ells you will use to connect the pipes are field cut or factory made.

c. Use the chart below to find the length of the take out you will use to connect these pipes.

Pipe Size	Take out Field Cut 45's	Take out Factory Made 45's
$\frac{1}{2}$"	0.625"	0.625"
$\frac{3}{4}$"	0.4660"	0.4375"
1"	0.6213"	0.875"
$1\frac{1}{4}$"	0.7767"	1"
$1\frac{1}{2}$"	0.9320"	1.125"
2"	1.2426"	1.375"
$2\frac{1}{2}$"	1.5533"	1.75"
3"	1.8640"	2"
$3\frac{1}{2}$"	2.1746"	2.25"
4"	2.4853"	2.5"
5"	3.1066"	3.125"
6"	3.7279"	3.75"
8"	4.9706"	5"
10"	6.2132"	6.25"
12"	7.4558"	7.5"
14"	8.6985"	8.75"
16"	9.9411"	10"
18"	11.1838"	11.25"
20"	12.4264"	12.5"
22"	13.6690"	13.5"
24"	14.9117"	15"

Step 3 **Find the Offset**

a. From the length of the "face to face" distance, subtract 2 take outs.

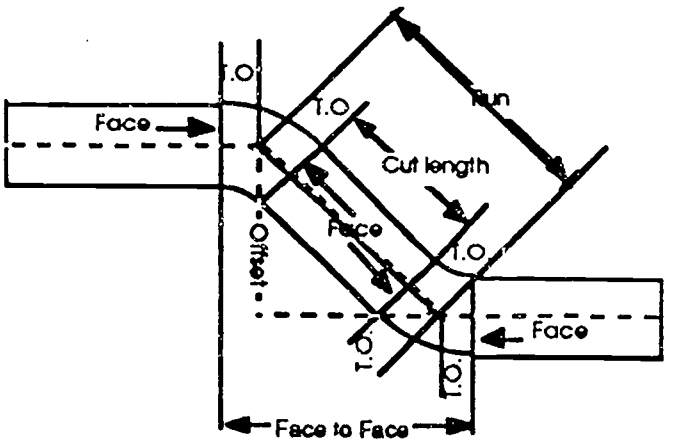


3

Step 4 **Find the Run** (the path from one center line to another center line).

a. The Csc 45° = 1.4142

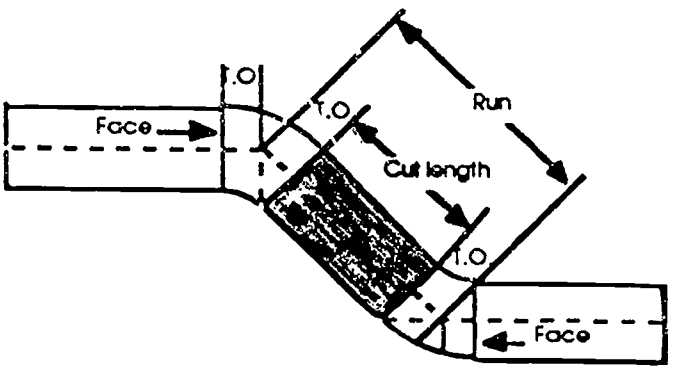
b. Multiply the Csc 45° (or 1.4142) x the Offset = Run



Step 5 **Find the cut length of pipe to connect the pipes.**

a. Use the formula:

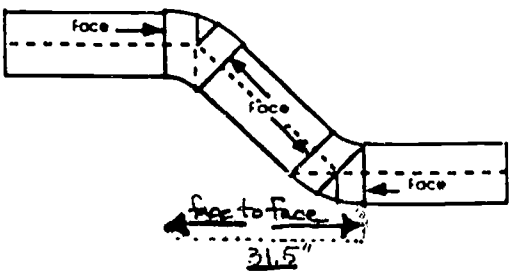
Run - 2 Take Outs - 2 Welder's Gaps = Cut Length



Example 1

Step 1 **Measure the "face to face" distance between the two pipes to be connected.**

a. Measure from the bottom of one pipe to the bottom of the second pipe (or the top to the top). The face to face is 31.5".

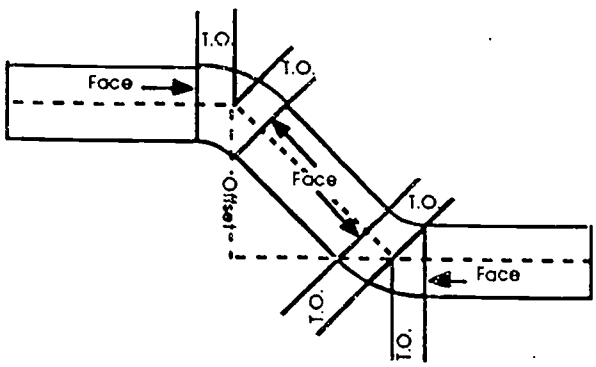


4

Step 2 **Find the "take out"** (the distance an ell extends the center line of a run of pipe past the end of a pipe).

a. The size of the pipe is 6".
b. The ells are factory made.
c. The take out for a 6" factory made ell is 3.75".

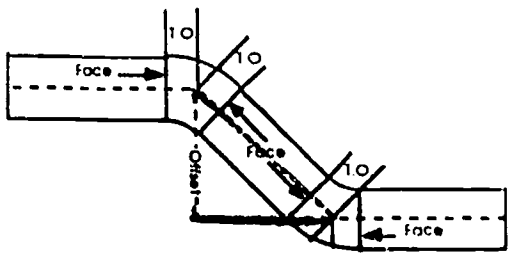
Pipe Size	Take out Field Cut 45's	Take out Factory Made 45's
$\frac{1}{2}$"	0.625"	0.625"
$\frac{3}{4}$"	0.4660"	0.4375"
1"	0.6213"	0.875"
$1\frac{1}{4}$"	0.7767"	1"
$1\frac{1}{2}$"	0.9320"	1.125"
2"	1.2426"	1.375"
$2\frac{1}{2}$"	1.5533"	1.75"
3"	1.8640"	2"
$3\frac{1}{2}$"	2.1746"	2.25"
4"	2.4853"	2.5"
5"	3.1066"	3.125"
6"	3.7279"	3.75"
8"	4.9706"	5"
10"	6.2132"	6.25"
12"	7.4558"	7.5"
14"	8.6985"	8.75"
16"	9.9411"	10"
18"	11.1838"	11.25"
20"	12.4264"	12.5"
22"	13.6690"	13.5"
24"	14.9117"	15"



Step 3 **Find the Offset**

a. From the length of the "face to face" distance, subtract 2 take outs.

Face to Face - 2 Take Outs = Offset
31.5" - 2(3.75") = Offset
31.5" - 7.5" = Offset
24" = **Offset**



5

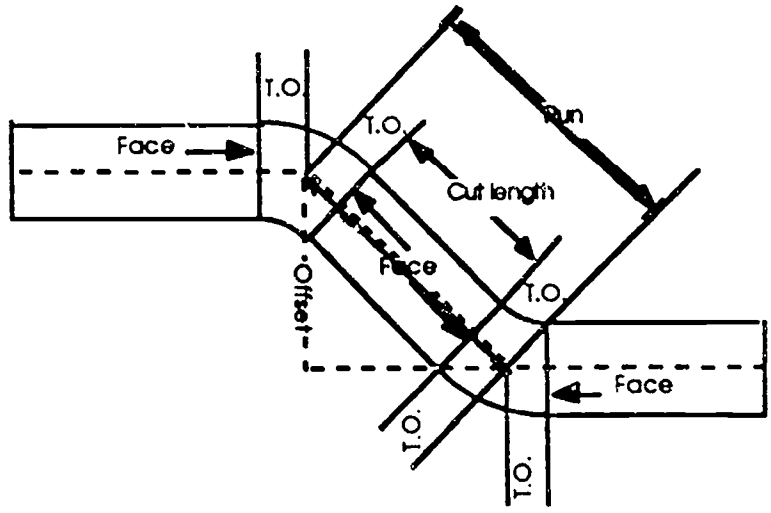
Step 4 **Find the Run** (the path from one center line to another center line).

a. The Csc 45° = 1.4142

b. Multiply the Csc 45° (or 1.4142) x the **Offset** = Run

1.4142 x 24" = Run

33.94" = Run

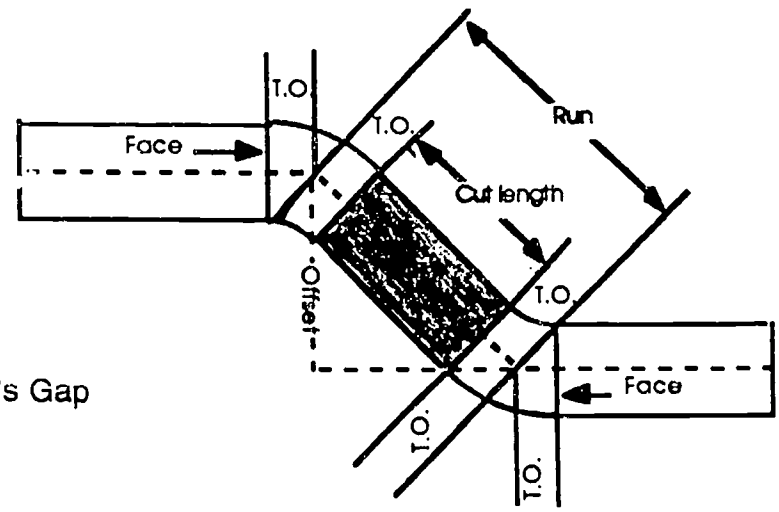


Step 5 **Find the cut length of pipe to connect the pipes.**

a. Use the formula:

Run - 2 Take Outs - 2 Welder's Gaps* = Cut Length

33.94" - 2(3.75")	- 2 (⅛")	= Cut Length
33.94" - 7.5"	- 2/8"	= Cut Length
33.94" - 7.5"	- .25"	= Cut Length
	26.19"	= Cut Length



* Use ⅛" for the Welder's Gap

Example 2 The distance between two 4" pipes that you want to connect is 28" using 45° 4" ells. How long will the cut length of your connecting pipe be?

Step 1 The "face to face" distance between the two pipes is 28".

Step 2 Find the take out for a 4" factory made ell from the chart below.

Step 3 Find the Offset

Face to Face - 2 Take Outs = Offset
28" - 2(") = Offset
28" - " = Offset
? " = Offset

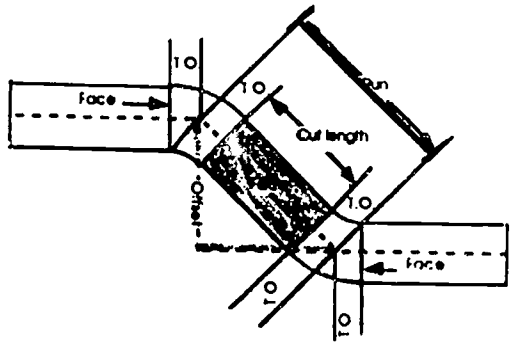
Step 4 Find the Run

Multiply the Csc 45° (or 1.4142) x the Offset = Run
1.4142 x ___" = Run
? " = Run

Step 5 Find the cut length of pipe to connect the pipes.

Run - 2 Take Outs - 2 Welder's Gaps* = Cut Length
" - 2(") - 2 (⅛") = Cut Length
" - " - 2/8" = Cut Length
" - " - .25" = Cut Length
? " = Cut Length

Pipe Size	Take out Field Cut 45's	Take out Factory Made 45's
½"	0.625"	0.625"
¾"	0.4660"	0.4375"
1"	0.6213"	0.875"
1¼"	0.7767"	1"
1½"	0.9320"	1.125"
2"	1.2426"	1.375"
2½"	1.5533"	1.75"
3"	1.8640"	2"
3½"	2.1746"	2.25"
4"	2.4853"	2.5"
5"	3.1066"	3.125"
6"	3.7279"	3.75"
8"	4.9706"	5"



Pipefitting Problems

Now try to do the following problems. Go back to the example problems if you need help.

1. The face to face distance between two 3" pipes that will be connected with factory made 45° ells is 40". What is the cut length of pipe needed to connect these pipes. (The answer is on page 12.)

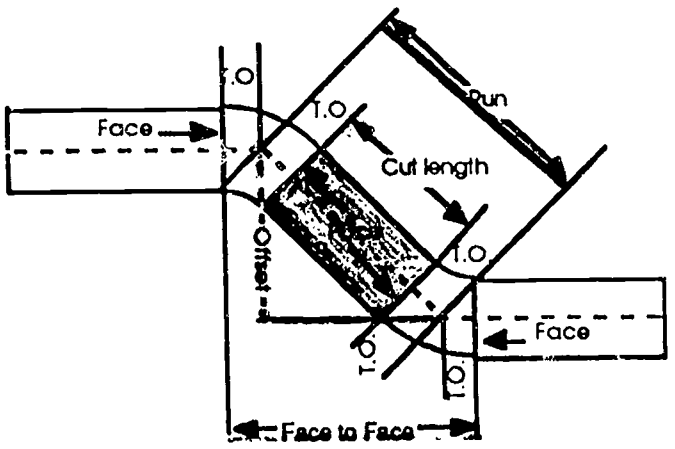
Step 1

Step 2

Step 3

Step 4

Step 5



2. The face to face distance between two 8" pipes that will be connected with factory made 45° ells is 72". What is the cut length of pipe needed to connect these pipes.

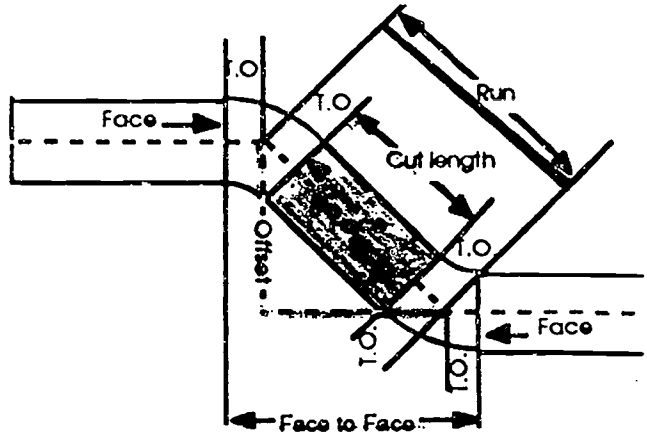
Step 1

Step 2

Step 3

Step 4

Step 5



3. The face to face distance between two 16" pipes that will be connected with factory made 45° ells is 200". What is the cut length of pipe needed to connect these pipes.

Step 1

Step 2

Step 3

Step 4

Step 5

Pipe Size	Take out Field Cut 45's	Take out Factory Made 45's
$\frac{1}{2}$"	0.625"	0.625"
$\frac{3}{4}$"	0.4660"	0.4375"
1"	0.6213"	0.875"
$1\frac{1}{4}$"	0.7767"	1"
$1\frac{1}{2}$"	0.9320"	1.125"
2"	1.2426"	1.375"
$2\frac{1}{2}$"	1.5533"	1.75"
3"	1.8640"	2"
$3\frac{1}{2}$"	2.1746"	2.25"
4"	2.4853"	2.5"
5"	3.1066"	3.125"
6"	3.7279"	3.75"
8"	4.9706"	5"
10"	6.2132"	6.25"
12"	7.4558"	7.5"
14"	8.6985"	8.75"
16"	9.9411"	10"
18"	11.1838"	11.25"
20"	12.4264"	12.5"
22"	13.6690"	13.5"
24"	14.9117"	15"

4. The face to face distance between two 20" pipes that will be connected with factory made 45° ells is 10' (or 120"). What is the cut length of pipe needed to connect these pipes.

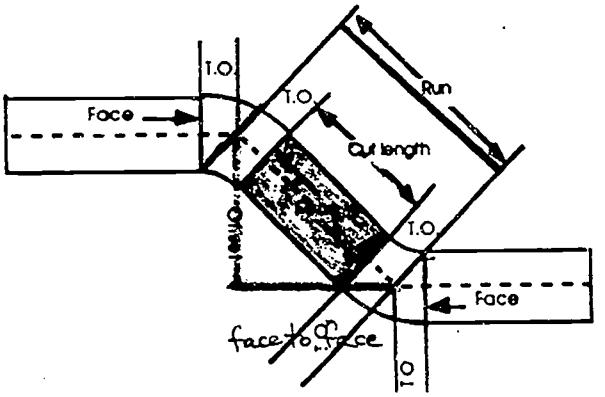
Step 1

Step 2

Step 3

Step 4

Step 5



5. The face to face distance between two 24" pipes that will be connected with factory made 45° ells is 12' (12" x 12' = 144"). What is the cut length of pipe needed to connect these pipes.

Step 1

Step 2

Step 3

Step 4

Step 5

Pipe Size	Take out Field Cut 45's	Take out Factory Made 45's
$\frac{1}{2}$"	0.625"	0.625"
$\frac{3}{4}$"	0.4660"	0.4375"
1"	0.6213"	0.875"
$1\frac{1}{4}$"	0.7767"	1"
$1\frac{1}{2}$"	0.9320"	1.125"
2"	1.2426"	1.375"
$2\frac{1}{2}$"	1.5533"	1.75"
3"	1.8640"	2"
$3\frac{1}{2}$"	2.1746"	2.25"
4"	2.4853"	2.5"
5"	3.1066"	3.125"
6"	3.7279"	3.75"
8"	4.9706"	5"
10"	6.2132"	6.25"
12"	7.4558"	7.5"
14"	8.6985"	8.75"
16"	9.9411"	10"
18"	11.1838"	11.25"
20"	12.4264"	12.5"
22"	13.6690"	13.5"
24"	14.9117"	15"

ANSWERS

1. The face to face distance between two 3" pipes that will be connected with factory made 45° ells is 40". What is the cut length of pipe needed to connect these pipes.

Step 1 The "face to face" distance between the two pipes is 40".

Step 2 The take out for a 3" factory made ell is 2".

Step 3 The Offset is:

Face to Face	- 2 Take Outs	= Offset
40"	- 2(3")	= Offset
40"	- 6"	= 34"

Step 4 The run is:

1.4142	x	34 "	= Run
		48.08 "	= Run

Step 5 The cut length of pipe is:

Run	- 2 Take Outs	- 2 Welder's Gaps*	= Cut Length
48"	- 2(2")	- 2 (⅛")	= Cut Length
48"	- 4"	- 2/8"	= Cut Length
48"	- 4"	- .25"	= Cut Length
		43.75"	= Cut Length

2. The face to face distance between two 8" pipes that will be connected with factory made 45° ells is 72". What is the cut length of pipe needed to connect these pipes.

Step 1 The "face to face" distance between the two pipes is 72".

Step 2 The take out for an 8" factory made ell is 5".

Step 3 The Offset is:

Face to Face	- 2 Take Outs	= Offset
72"	- 2(5")	= Offset
72"	- 10"	= 62"

Step 4 The run is:

1.4142	x	62 "	= Run
		87.68"	= Run

Step 5 The cut length of pipe is:

Run	- 2 Take Outs	- 2 Welder's Gaps	= Cut Length
87.68"	- 2(5")	- 2 (⅛")	= Cut Length
87.68"	- 10"	- 2/8"	= Cut Length
87.68"	- 10"	- .25"	= 77.43"

3. The face to face distance between two 16" pipes that will be connected with factory made 45° ells is 200". What is the cut length of pipe needed to connect these pipes.

Step 1 The "face to face" distance between the two pipes is 200".

Step 2 The take out for a 16" factory made ell is 10".

Step 3 The Offset is:

Face to Face	- 2 Take Outs	= Offset
200"	- 2(10")	= Offset
200"	- 20"	= 180"

Step 4 The run is:

1.4142	x	180"	= Run
		254.56"	= Run

Step 5 The cut length of pipe is:

Run	- 2 Take Outs	- 2 Welder's Gaps	= Cut Length
254.56"	- 2(10")	- 2 (⅛")	= Cut Length
254.56"	- 20"	- 2/8"	= Cut Length
254.56"	- 20"	- .25"	= 234.31"

4. The face to face distance between two 20" pipes that will be connected with factory made 45° ells is 10' (or 120"). What is the cut length of pipe needed to connect these pipes.

Step 1 The "face to face" distance between the two pipes is 120".

Step 2 The take out for a 20" factory made ell is 12.5".

Step 3 The Offset is:

Face to Face	- 2 Take Outs	= Offset
120"	- 2(12.5")	= Offset
120"	- 25"	= 95"

Step 4 The run is:

1.4142	x	95"	= Run
		134.35"	= Run

Step 5 The cut length of pipe is:

Run	- 2 Take Outs	- 2 Welder's Gaps	= Cut Length
134.35"	- 2(12.5")	- 2 (⅛")	= Cut Length
134.35"	- 25"	- 2/8"	= Cut Length
134.35"	- 25"	- .25"	= 109.1"

5. The face to face distance between two 24" pipes that will be connected with factory made 45° ells is 12' (12" x 12' = 144"). What is the cut length of pipe needed to connect these pipes.

Step 1 The "face to face" distance between the two pipes is 144".

Step 2 The take out for a 24" factory made ell is 15".

Step 3 The **Offset** is:

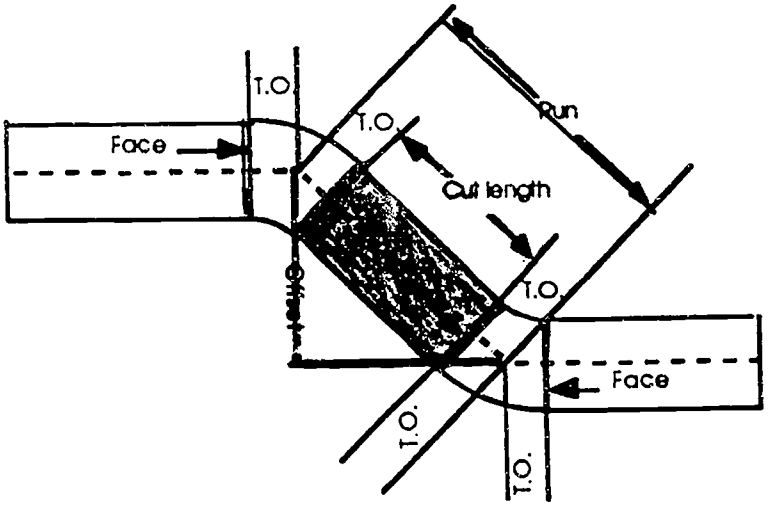
Face to Face	- 2 Take Outs	= Offset
144"	- 2(15")	= Offset
144"	- 30"	= 114"

Step 4 The run is:

1.4142	x	114"	= Run
		161.22"	= Run

Step 5 The cut length of pipe is:

Run	- 2 Take Outs	- 2 Welder's Gap	= Cut Length
161.22"	- 2(15")	- 2 (⅛")	= Cut Length
161.22"	- 30"	- 2/8"	= Cut Length
161.22"	- 30"	- .25"	= 130.97"

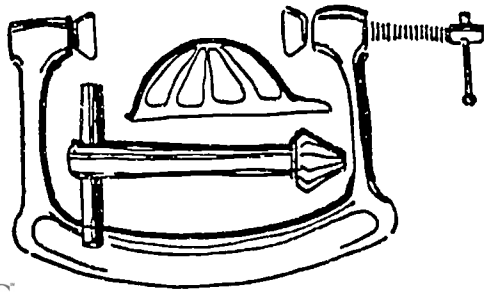


Run - 2 T.O. - 2 gaps = cut length

13

TECHNICAL DEVELOPMENT CENTER

Practicing Problem Solving for Pipefitters



Associated Builders & Contractors, Inc.
EBR Adult & Continuing Education

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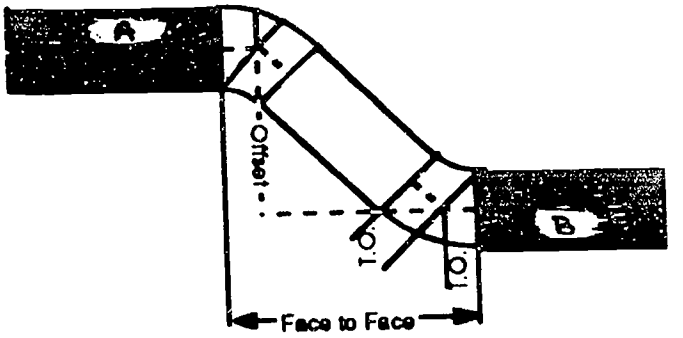
Problem Solving Exercises

In the problems below use the pipes labeled "A", "B", "C", "D", "E", "F" and "G" located in the TDC center classroom. These colored plastic pipes are located on the movable wall between the teacher's desk and the classroom tables. For purposes of these exercises we will use plastic rather than metal pipes as they are easier to use even though butt welding is used on metal pipes.

Example

How long is the cut length of the connecting pipe between the two blue, 2" pipes labeled "A" and "B"?

Step 1 Measure the "face to face" distance between the blue pipes.



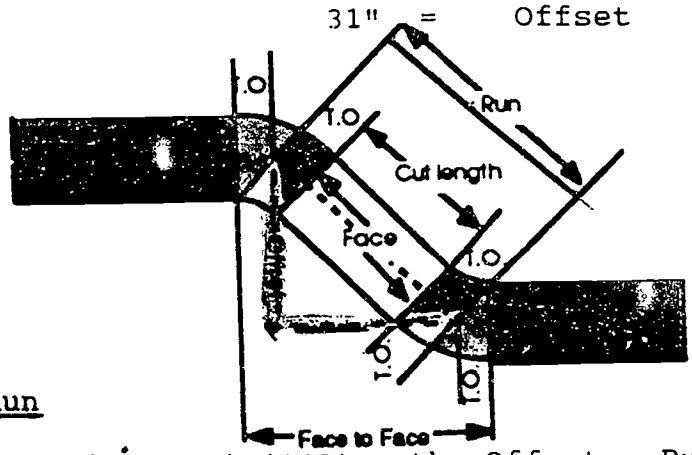
Step 2 Find the take out for a 2" factory made ell from the chart below.

Pipe Size	Take out Field Cut 45's	Take out Factory Made 45's
$\frac{1}{2}$"	0.625"	0.625"
$\frac{3}{4}$"	0.4660"	0.4375"
1"	0.6213"	0.875"
$1\frac{1}{4}$"	0.7767"	1"
$1\frac{1}{2}$"	0.9320"	1.125"
2"	1.2426"	1.375"
$2\frac{1}{2}$"	1.5533"	1.75"
3"	1.8640"	2"
$3\frac{1}{2}$"	2.1746"	2.25"
4"	2.4853"	2.5"
5"	3.1066"	3.125"
6"	3.7279"	3.75"
8"	4.9706"	5"
10"	6.2132"	6.25"
12"	7.4558"	7.5"
14"	8.6985"	8.75"
16"	9.9411"	10"
18"	11.1838"	11.25"
20"	12.4264"	12.5"
22"	13.6690"	13.5"
24"	14.9117"	15"

Take Out for a 2" factory made 45 ell is 1.375"

Step 3 Find the [redacted]

Face to Face	- 2(Take Outs)	=	Offset
33.75"	- 2(1.375")	=	Offset
33.75"	- 2.75"	=	Offset
	31"	=	Offset



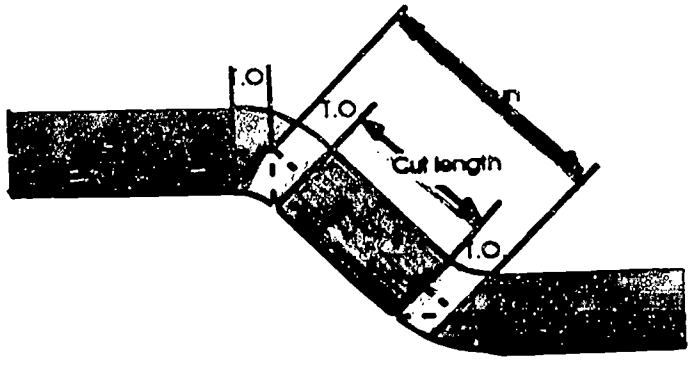
Step 4 Find the Run

Multiply the Csc 45° (or 1.4142) x the Offset = Run

1.4142	x 31"	= Run
	43.8402"	= Run

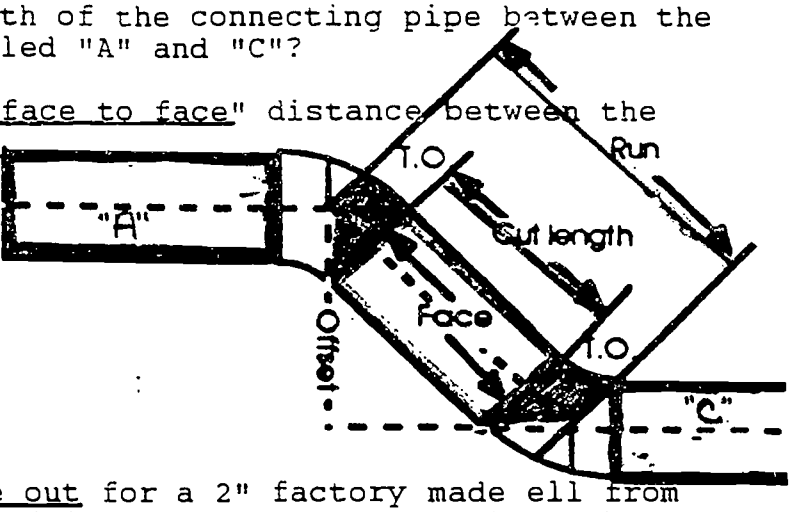
Step 5 Find the cut length of pipe to connect the pipes.

Run	- 2Take Outs	- 2 Welder's Gaps	= Cut Length
43.84"	- 2(1.375")	- 2 (1/8")	= Cut Length
43.84"	- 2.75	- 2/8"	= Cut Length
43.84"	- 2.75	- .25"	= Cut Length
		40.84"	= Cut Length



1. How long is the cut length of the connecting pipe between the two blue, 2" pipes labeled "A" and "C"?

Step 1 Measure the "face to face" distance between the two pipes.



Step 2 Find the take out for a 2" factory made ell from the chart found in Step 2 of the example problem (2 pages before).

Take Out for a 2" factory made ell = ? "

Step 3 Find the **Offset**

Face to Face - 2(Take Outs) = Offset

?

Step 4 Find the Run

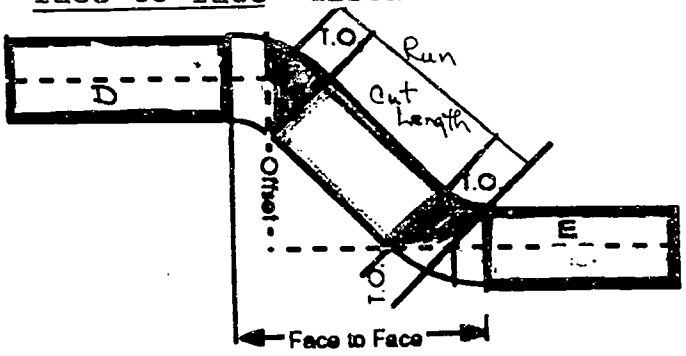
Multiply the Csc 45°(or 1.4142) x the Offset = Run
1.4142 x = Run
? = Run

Step 5 Find the cut length of pipe to connect the pipes.

Run - 2 Take Outs - 2 Welder's Gaps = Cut Length
" - 2 (") - 2 (1/8") = Cut Length
" - - 2/8" = Cut Length
" - - .25" = Cut Length
? = Cut Length

2. How long is the cut length of the connecting pipe between the two orange 3/4" pipes labeled "D" and "E"?

Step 1 Measure the "face to face" distance between the two pipes.



Step 2 Find the take out for a 3/4" factory made ell from the chart found in Step 2 of the example problem (3 pages before).

Take Out for 3/4" factory made ell = ? "

Step 3 Find the **Offset**

Face to Face - 2(Take Outs) = Offset

?

Step 4 Find the Run

Multiply the Csc 45° (or 1.4142) x the Offset = Run

1.4142 x = Run

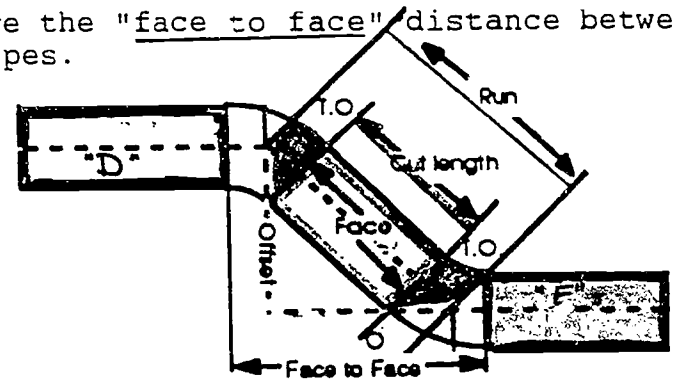
? = Run

Step 5 Find the cut length of pipe to connect the pipes.

Run	- 2 Take Outs	- 2 Welder's Gaps	= Cut Length
"	- 2 (")	- 2 (1/8")	= Cut Length
"	-	- 2/8"	= Cut Length
"	-	- .25"	= Cut Length
		?	= Cut Length

3. How long is the cut length of the connecting pipe between the orange 3/4" pipe labeled "D" and the green 3/4" pipe labeled "F"?

Step 1 Measure the "face to face" distance between the two pipes.



Step 2 Find the take out for a 3/4" factory made ell from the chart found in Step 2 of the example problem (**4** pages before).

Take Out for 3/4" factory made ell = ? "

Step 3 Find the Offset

Face to Face - 2(Take Outs) = Offset

?

Step 4 Find the Run

Multiply the Csc 45° (or 1.4142) x the Offset = Run

1.4142 x = Run

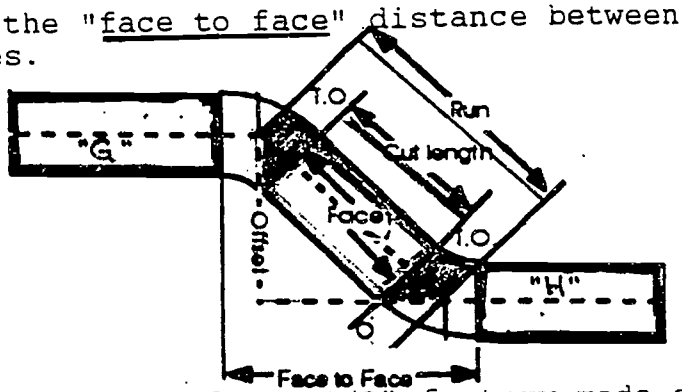
? = Run

Step 5 Find the cut length of pipe to connect the pipes.

Run	- 2 Take Outs	- 2 Welder's Gaps	= Cut Length
"	- 2 (")	- 2 (1/8")	= Cut Length
"	-	- 2/8"	= Cut Length
"	-	- .25"	= Cut Length
		?	= Cut Length

4. How long is the cut length of the connecting pipe between the yellow 1 1/2" pipes labeled "G" and "H"?

Step 1 Measure the "face to face" distance between the two pipes.



Step 2 Find the take out for 1 1/2" factory made ell from the chart found in Step 2 of the example problem (chart on page 1).

Take Out for 1 1/2" factory made ell = ____? "

Step 3 Find the **Offset**

Face to Face - 2(Take Outs) = Offset
? ?

Step 4 Find the Run

Multiply the Csc 45 (or 1.4142) x the Offset = Run
1.4142 x = Run
? = Run

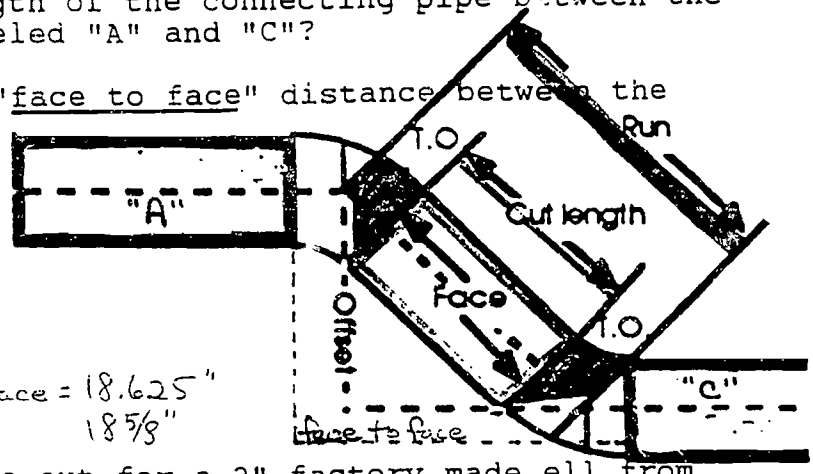
Step 5 Find the cut length of pipe to connect the pipes.

Run	- 2 Take Outs	- 2 Welder's Gaps	= Cut Length
"	- 2 (")	- 2 (1/8")	= Cut Length
"	-	- 2/8"	= Cut Length
"	-	- .25"	= Cut Length
			? = Cut Length

Answers

1. How long is the cut length of the connecting pipe between the two blue, 2" pipes labeled "A" and "C"?

Step 1 Measure the "face to face" distance between the two pipes.



face to face = 18.625"
18 5/8"

Step 2 Find the take out for a 2" factory made ell from the chart found in Step 2 of the example problem (2 pages before).

Take Out for a 2" factory made ell = 1.375 "

Step 3 Find the **Offset**

Face to Face	- 2(Take Outs)	=	Offset
18 5/8"	- 2(1.375")	=	Offset
18.625"	- 2.75"	=	Offset
	15.875"	=	Offset

Step 4 Find the [redacted]

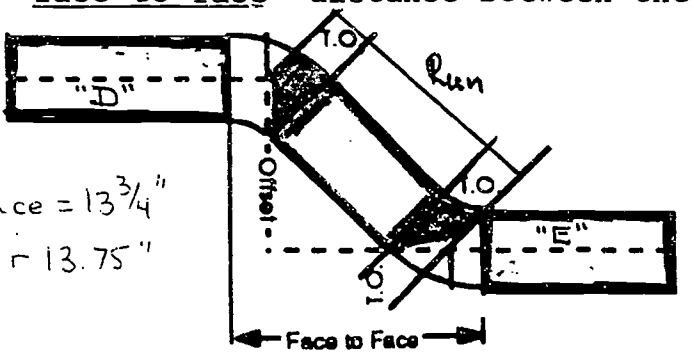
Multiply the Csc 45° (or 1.4142) x the Offset = Run
1.4142 x " = Run
22.45" = Run

Step 5 Find the cut length of pipe to connect the pipes.

Run	- 2 Take Outs	- 2 Welder's Gaps	= Cut Length
22.45 "	- 2 (1.375")	- 2 (1/8")	= Cut Length
22.45 "	- 2.75"	- 2/8"	= Cut Length
22.45 "	- 2.75"	- .25"	= Cut Length
		19.45"	= Cut Length

2. How long is the cut length of the connecting pipe between the two orange 3/4" pipes labeled "D" and "E"?

Step 1 Measure the "face to face" distance between the two pipes.



face to face = 13 3/4"
or 13.75"

Step 2 Find the take out for a 3/4" factory made ell from the chart found in Step 2 of the example problem (3 pages before).

Take Out for 3/4" factory made ell = .4375 "

Step 3 Find the **Offset**

Face to Face	- 2(Take Outs)	=	Offset
13.75"	- 2(.4375")	=	Offset
13.75"	- .875"	=	Offset
		12.875" =	Offset

Step 4 Find the Run

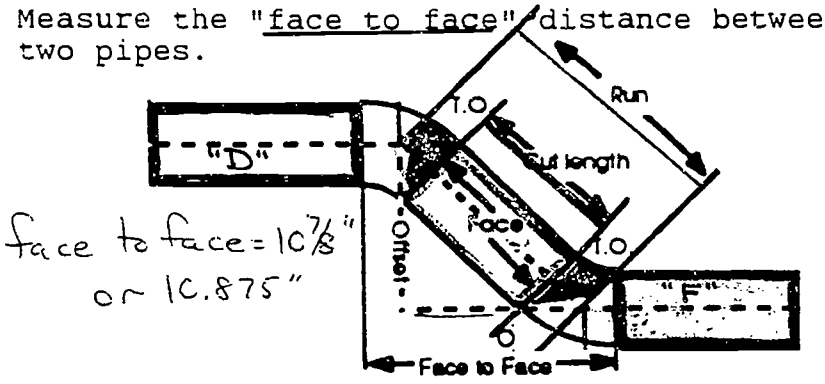
Multiply the Csc 45° (or 1.4142) x the Offset = Run
1.4142 x 12.875" = Run
18.21" = Run

Step 5 Find the cut length of pipe to connect the pipes.

Run	- 2 Take Outs	- 2 Welder's Gaps	= Cut Length
18.21"	- 2 (.4375")	- 2 (1/8")	= Cut Length
18.21"	- .875"	- 2/8"	= Cut Length
18.21"	- .875"	- .25"	= Cut Length
		17.085"	= Cut Length

3. How long is the cut length of the connecting pipe between the orange 3/4" pipe labeled "D" and the green 3/4" pipe labeled "F" ?

Step 1 Measure the "face to face" distance between the two pipes.



face to face = 10 7/8" or 10.875"

Step 2 Find the take out for a 3/4" factory made ell from the chart found in Step 2 of the example problem (3 pages before).

Take Out for 3/4" factory made ell = .4375 "

Step 3 Find the Offset

Face to Face - 2(Take Outs) = Offset

10.875" - 2(.4375") = Offset

10.875" - .875" = Offset

10" = Offset

Step 4 Find the Run

Multiply the Csc 45° (or 1.4142) x the Offset = Run

1.4142 x 10" = Run

14.142" = Run

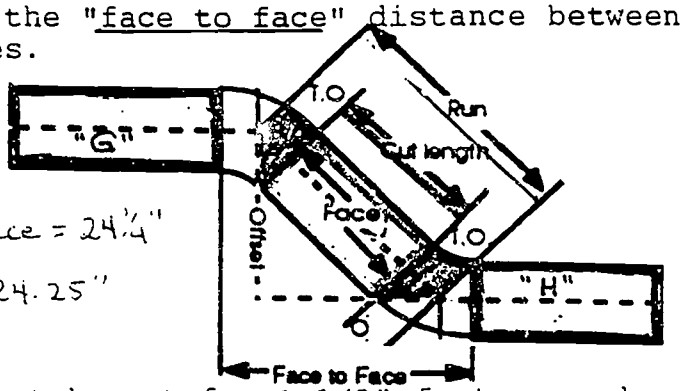
Step 5 Find the cut length of pipe to connect the pipes.

Run	- 2 Take Outs	- 2 Welder's Gaps	= Cut Length
14.142 "	- 2 (.4375")	- 2 (1/8")	= Cut Length
14.142 "	- .875"	- 2/8"	= Cut Length
14.142 "	- .875"	- .25"	= Cut Length
			13.017" = Cut Length

4. How long is the cut length of the connecting pipe between the yellow 1 1/2" pipes labeled "G" and "H"?

Step 1 Measure the "face to face" distance between the two pipes.

face to face = 24¼"
or 24.25"



Step 2 Find the take out, for 1 1/2" factory made ell from the chart found in Step 2 of the example problem (4 pages before).

Take Out for 1 1/2" factory made ell = 1.125 "

Step 3 Find the Offset

Face to Face	- 2(Take Outs)	=	Offset
24.25"	- 2(1.125")	=	~~Offset~~
24.25"	- 2.25"	=	Offset
	22"	=	Offset

Step 4 Find the Run

Multiply the Csc 45 (or 1.4142) x the Offset = Run

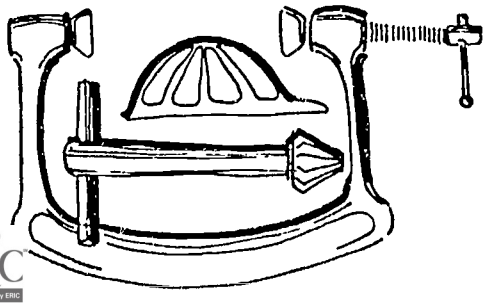
1.4142	x	22"	= Run
		31.1124"	= Run

Step 5 Find the cut length of pipe to connect the pipes.

Run	- 2 Take Outs	- 2 Welder's Gaps	= Cut Length
31.11" "	- 2 (1.125")	- 2 (1/8")	= Cut Length
31.11 "	- 2.25"	- 2/8"	= Cut Length
31.11 "	- 2.25"	- .25"	= Cut Length
		28.61"	= Cut Length

TECHNICAL DEVELOPMENT CENTER

Basic Vocabulary for Pipefitters



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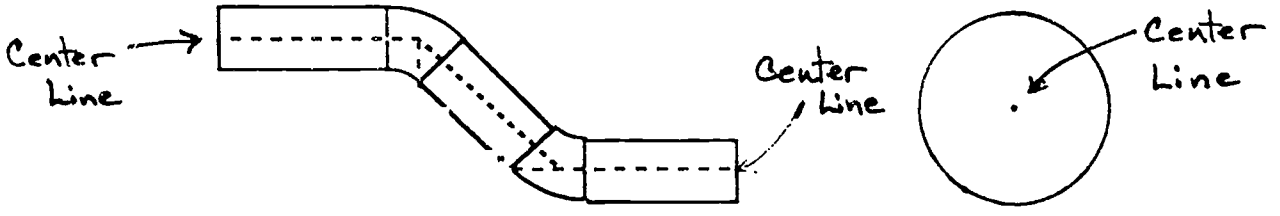
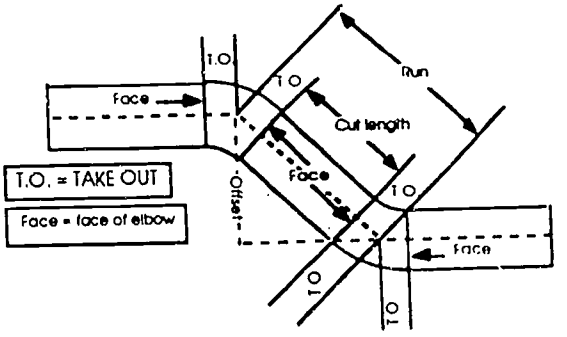
Pipefitter Vocabulary

Many of the vocabulary words pipefitters use are listed on pages 1 - 4. Practice using these words in the exercises beginning on page 5.

Center Line - The line that is equal distant from all sides of a pipe that is in the middle of a pipe. A center line goes along the very middle of a pipe. (To know where to find the center line, we could think of it as in a baked pie, it is the point where someone would first place a knife in order to cut out a piece of pie.)



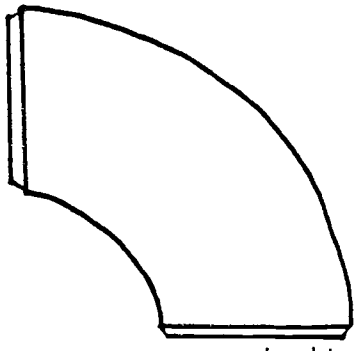
Cut Length - Is the length of the pipe needed to connect two pipes together (it does not include the take outs or welder's gaps included in the face to face distance between the pipes to be connected).



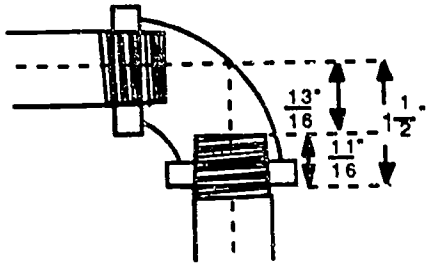
Elbows

There are three types of elbows used in pipefitting.

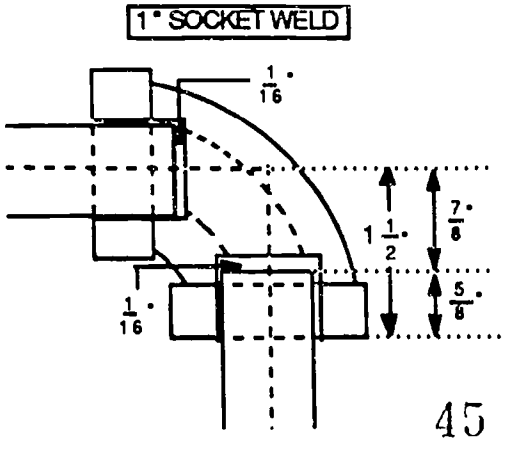
Butt Weld Elbows - Made of metal, a butt weld elbow can be cut and rebeveled to any angle that is needed. It is used to connect metal pipes. A butt weld elbow is a "welder's gap" away from the pipe it is connected to. Large metal pipes used in the petrochemical industry are welded together with butt weld elbows. These are often written as b.w. ells.



Screwed Elbows - These elbows are attached to a pipe by threads. The pipe which has male threads, is screwed into the elbow, which has female threads. The elbows are factory made, with the female threads already in place. The male threads on the pipe are cut into the pipe at the job site, using a threading machine.

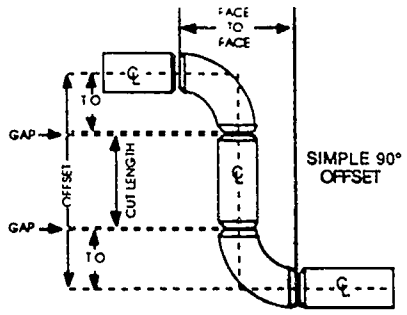


Socket Weld Elbows - A socket weld elbow has a hole, called a socket, cut into the faces of the elbow. The socket is a little larger than the outer diameter of the pipe. The pipe is put inside the socket of the fitting, pulled back 1/16", then tacked. After the fit is complete, a welder welds the pipe into the socket if it is made of metal.

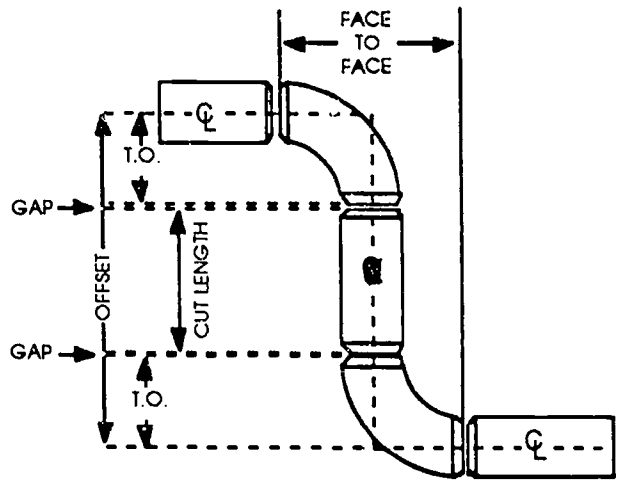


Factory Cut or Field Cut Elbows - When you work with 45° Butt Weld elbows, you must first decide if the elbow has been made either in a factory or by an individual on the job. Usually a factory made ell has stamped on the outside of the ell, "made by ___." If it is made by someone outside of a factory, it is called a "field cut" (someone made it in the field). How an ell is made will help you to know its correct size. Not all ells are made the same size. Generally, factory cut and field cut elbows have not been made with the same dimensions.

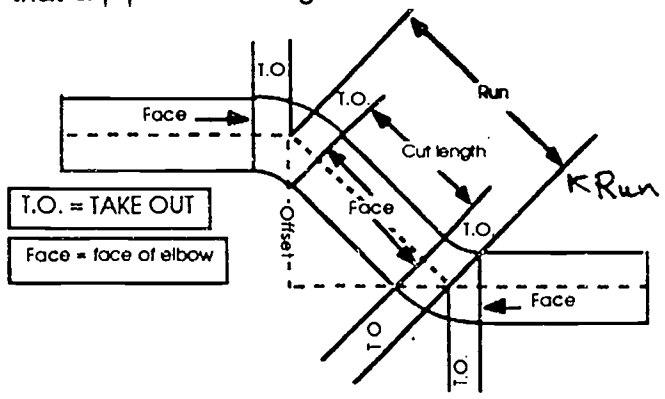
Face to Face - The distance between two pipes that are to be connected.



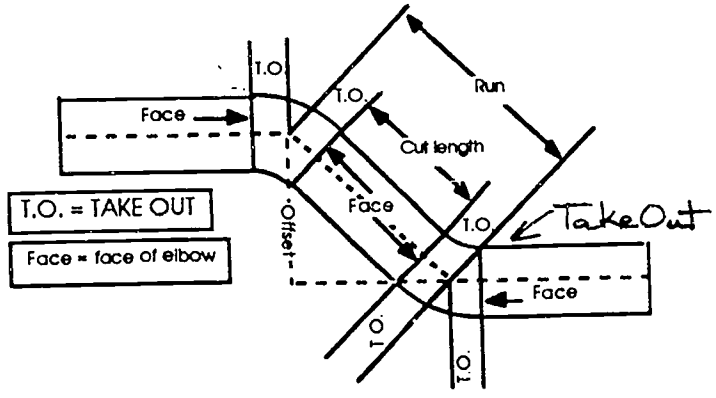
Offset - It is the distance between the center lines of two pipes. Usually it is a combination of two ells and a cut length of pipe that moves a line of pipe to a new position. When you are connecting two pipes that are level to the ground, it is called a **simple offset.** Most pipes in the industrial plants are laid in north/south or east/west directions. What you must do is figure the distance between the two pipes you want to connect.



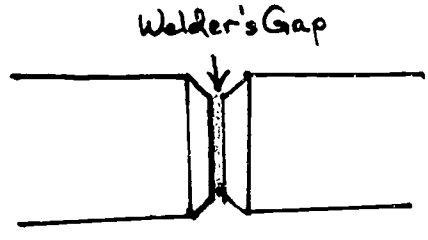
Run - The path that a pipe takes to get from one center line to another center line.



Take Out - The **take out** of a fitting is the distance that a fitting extends the center line of a run of pipe past the end of the pipe.



Welder's Gap - The space between a fitting and the pipe that is filled by a weld. It is the distance a welder leaves between a pipe and an elbow. The width of the gap is how much space a welder needs to make a good weld. It is best to ask the welder how wide a gap he/she wants before making any calculations. A common welder's gap is 3/32" or 1/4".



In the following problems what pipefitter vocabulary word best fits each problem? Number a blank sheet of paper 1 - 15. Write down the pipefitter vocabulary word that is described in each problem. Answers can be found on page 7.

1. Jack must find out how long a piece of pipe he needs to connect two lines of pipe. The name of the connecting length of pipe is _____.

2. Pam wondered what the middle point within a pipe is called? It is the _____ _____.

3. Ronnie worked with a welder who liked him to leave 3/32" for his weld between a butt weld elbow and a pipe. This 3/32" is called a _____.

4. Winton makes his butt weld elbows at his job site. When a butt weld elbow is made at the job site it is called a _____ elbow.

5. Jessie found the distance between the center lines of two pipes was 12". This distance is called _____.

6. Jeff wanted to find out how much length an elbow added to the center line of a run of pipe past the face of the pipe. Jeff was trying to find the _____.

7. Jean noticed the elbows she was to use on a run had been threaded. This type of elbow is called a _____ elbow.

   Should the pipe connected with these elbows need to be threaded? _____

8. Lee picked up an elbow that had "made by Fisher" stamped on it. This type of elbow is called a _____ elbow.

In the diagram below use the vocabulary words found on pages 1 - 4 to label each part.

9. _____

10. _____

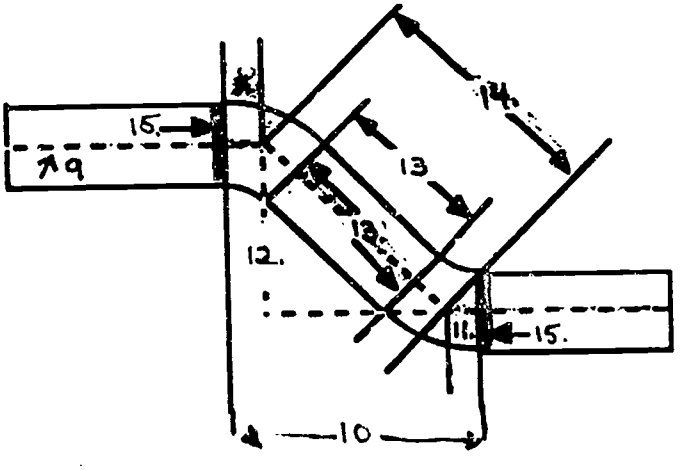
11. _____

12. _____

13. _____

14. _____

15. _____

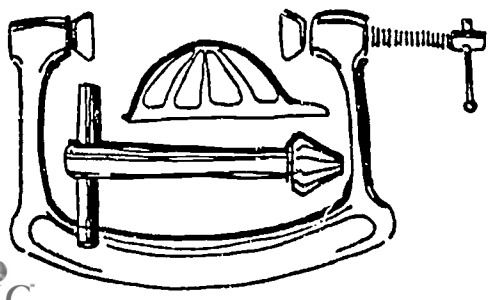


Answers

1. Cut Length
2. Center Line
3. Welder's Gap
4. Field Cut
5. Run
6. Take Out
7. Screwed, Yes
8. Factory Cut
9. Center Line
10. Face to Face
11. Take Out
12. Offset
13. Cut Length
14. Run
15. Face

TECHNICAL DEVELOPMENT CENTER

Basic Trig for Pipefitters



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Basic Trigonometry for Pipefitters

Trigonometry sounds hard. It isn't. It helps a pipefitter to do two things in order to figure how to connect two lines of pipe to complete a run.

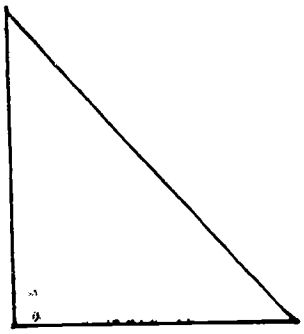
1. A pipefitter must be able to "see" a right triangle in an elbow.

2. Determine the lengths of the sides of the triangle to find an elbow's "take out." This information will be used to figure out the cut length of the connecting pipe.

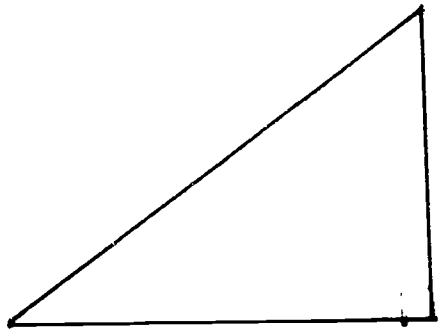
Seeing Right Triangles in Elbows

A right triangle has three sides and three angles. One angle is 90° (it looks like a corner of a box). Which of the triangles below are right triangles?

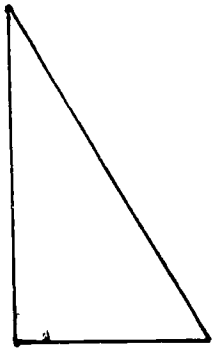
A.



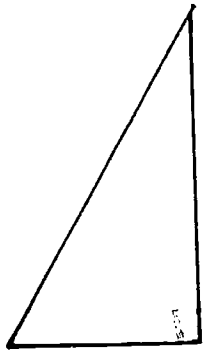
B.



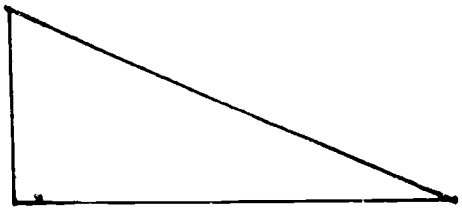
C.



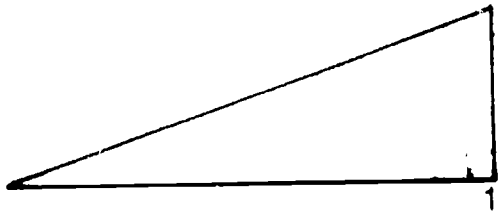
D.



E.



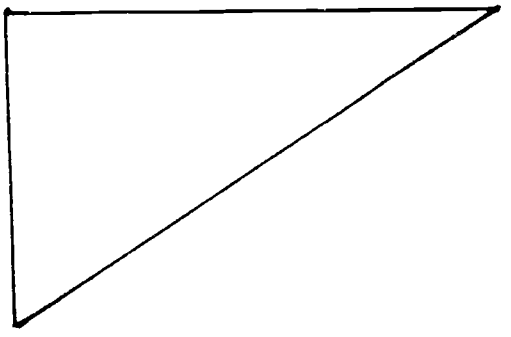
F.



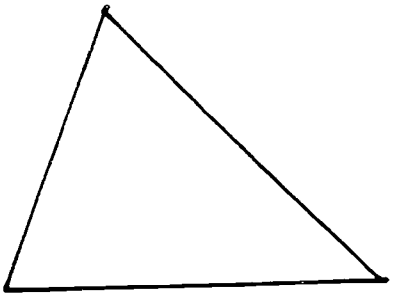
All the triangles (A, B, C, D, E, and F) were right triangles. They all had one angle that was 90°. The size of the other two angles doesn't matter.

Which of the triangles below are right triangles? (Remember, a right triangle must have one angle that is 90°.)

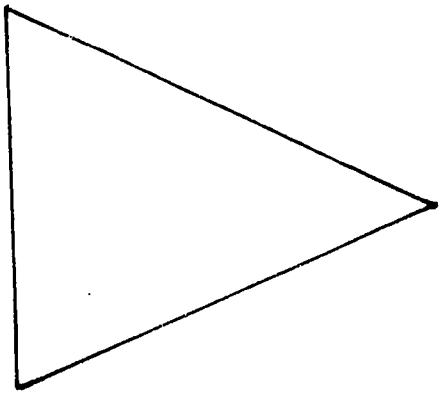
A.



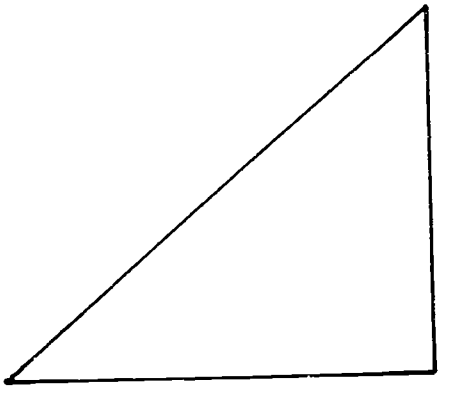
B.



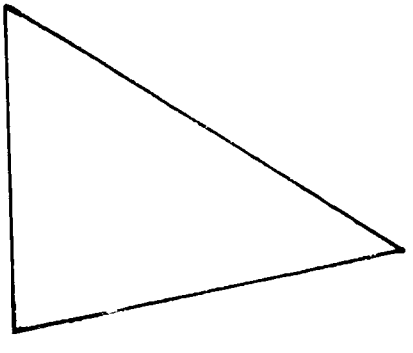
C.



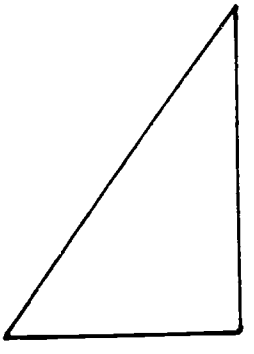
D.



E.



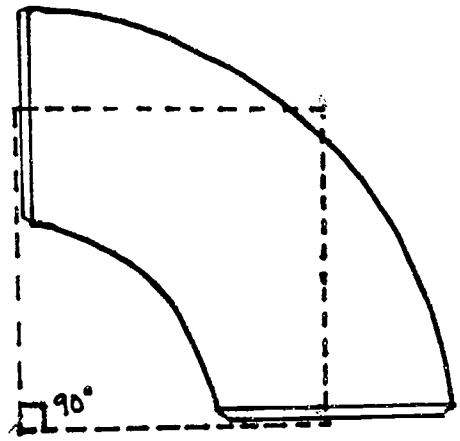
F.



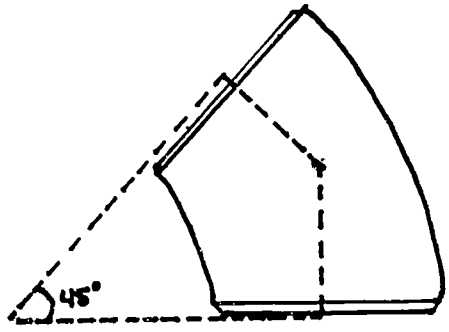
The triangles on page 2 that were right triangles were A, D, and F. They each had a 90° angle. Triangles B, C, and E were not right triangles because they did not have a 90° angle.

Look at the pictures of pipe elbows below and "see" how the right triangles have been drawn in them.

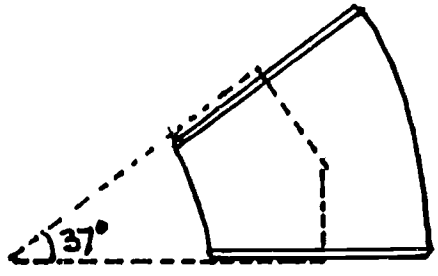
A. This is a 90° elbow.



B. This is a 45° elbow.

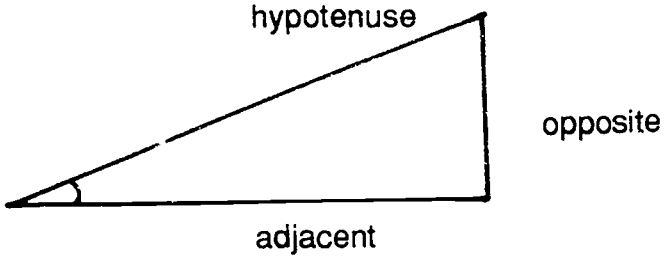


C. This is a 37° elbow.



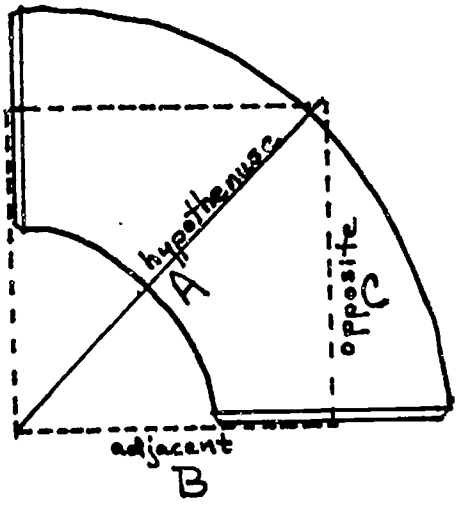
On another sheet of paper draw pictures of four different sizes of pipe elbows. Can you "find" the right triangles in them? Good luck.

Different sides of a triangle have special names. These names are:



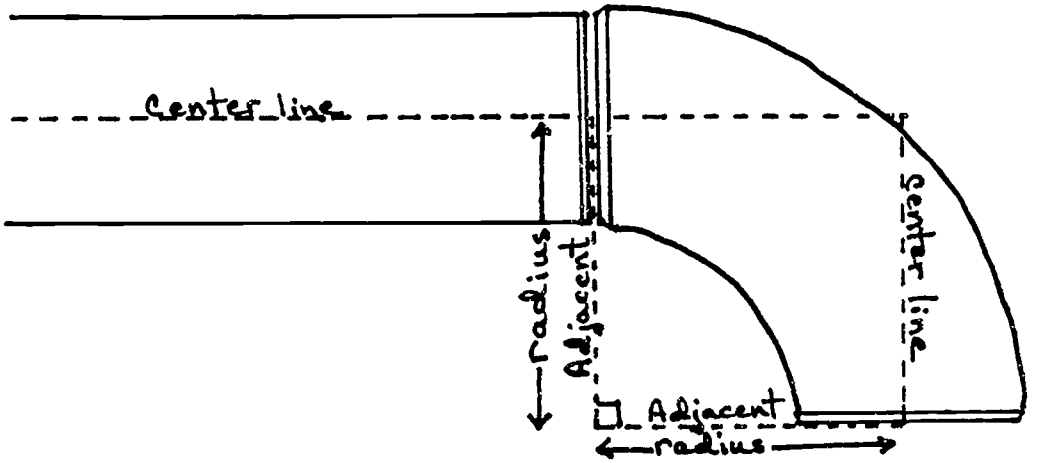
In the elbow pictured below which side of the triangle is the:

- hypotenuse
- adjacent side
- opposite side

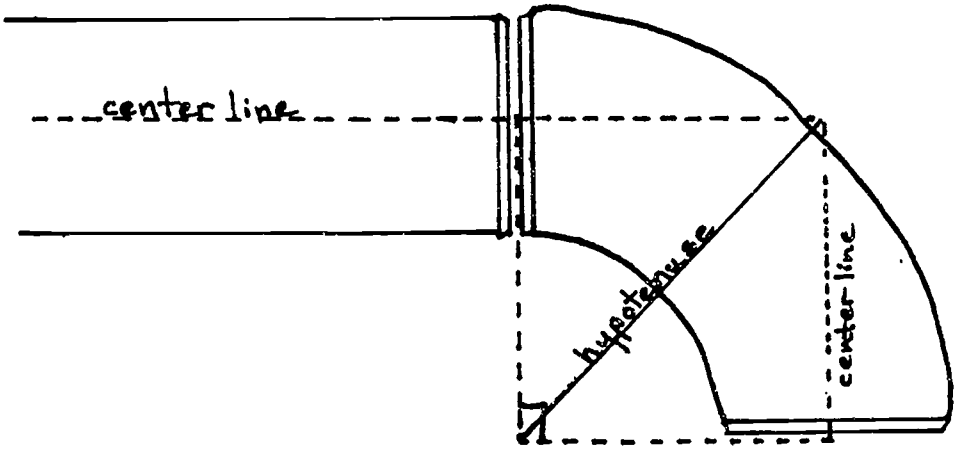


Answer: A = hypotenuse; B = adjacent; C = opposite

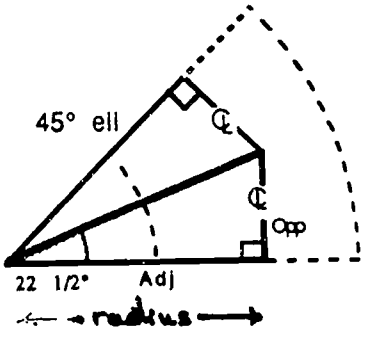
The "adjacent legs" of a right triangle are made up by the lines that come from the vertex of the elbow's angle which extend to the center lines of the pipe faces. This is also the radius of the elbow.

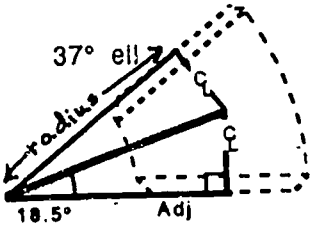


The hypotenuse is created by a line that divides the angle of the elbow. The hypotenuse ends at the point where the center lines of the elbow meet.



The drawings below show the adjacent sides are equal to the radius. The opposite sides are equal to the "take out" of an elbow.





Finding Take Outs

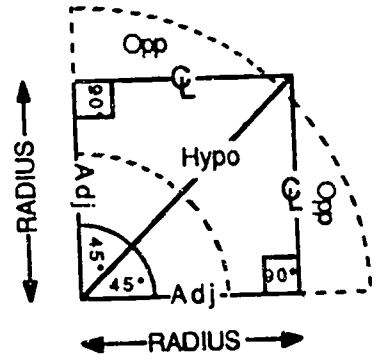
In the elbow below you know the following:

1. The angle (it is always half the angle of the elbow because its divided it in half), and

2. The size of the adjacent side (it is the same as the radius).

You do not know:

1. The length of the opposite side (which is also the **take out** of the elbow).



To find the opposite side, first "see" the right triangle in the elbow, then plug in what you know into this formula:

opposite = tan θ x adjacent

Let's look at this formula in a different way. Use the diagram above to review what you know: the **opposite side** is the **take out** of the ell, so we can replace **take out** with **opposite**.

take out of elbow = tan θ x adjacent

Next, we also know that the **adjacent side** of a right triangle is equal to the **radius** of the elbow.

take out of elbow = tan θ x radius of ell

We know, too, that the angle of the triangle is equal to ½ the angle of the elbow:

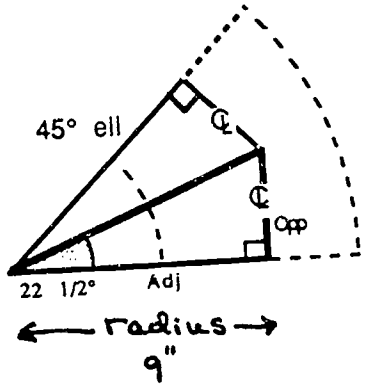
take out of elbow = tan $\frac{\theta}{2}$ of the ell x radius of ell

In the elbow below use the **take out** formula to find **take out:**

take out = $\tan \frac{\theta}{2}$ **x radius of ell**

takeout = 0.4142 x 9"

take out = 3.7278"

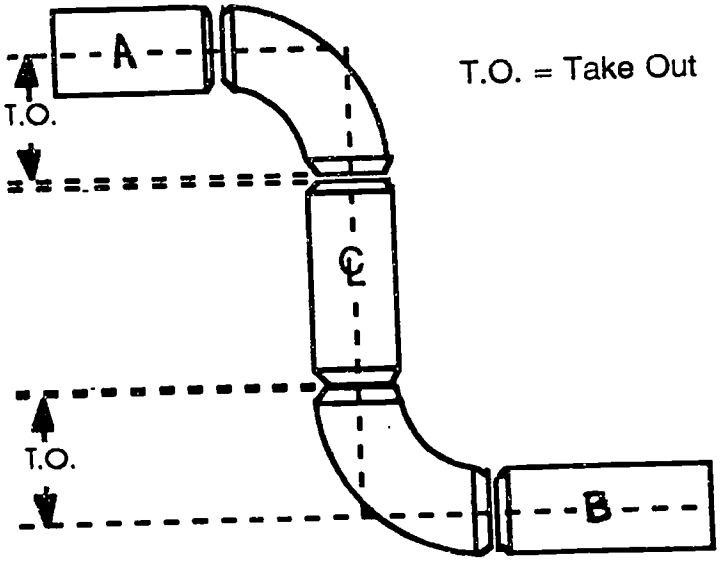


Radius = 9"

tan $\frac{\theta}{2}$ = 0.4142

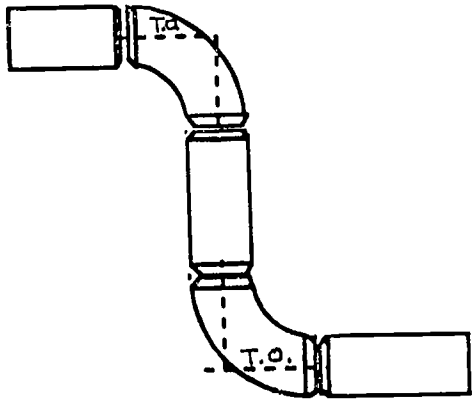
Take out is the length of pipe the elbow (ell) adds to a pipe offset. It is the distance an ell extends the center line of a run of pipe past the end of the pipe. To connect Pipe "A" to Pipe "B" in the example below, "**take out**" or how much length the elbows (ells) add to the length of a run of pipe, in order to connect these pipes together.

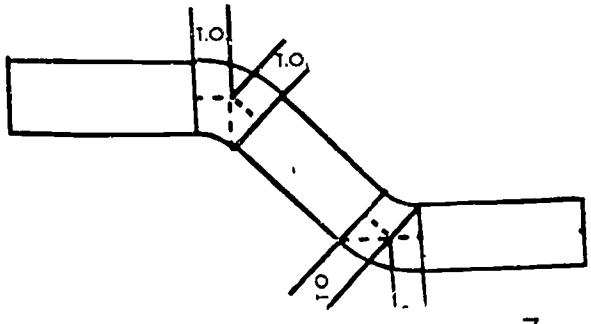
ex.



T.O. = Take Out

Below are some examples of **take outs**. Look at how much length a **take out** adds to a run of pipe. Different angles of elbows have different **take outs**.





In order to figure **take outs** you must be able to find the **Tangent** (**Tan**) of an angle. Use the chart below to find these **Tangents**:

45° **Tan** = 1.0000 22.5° **Tan** = 0.4142 56° **Tan** = 1.4826

To read this chart:

If the degree of the angle is less than 45°:

find the degree listed in the far left column marked "Deg" then find its Tan θ (5th column from left).

If the degree is greater than 45°:

read the degree in the far right column then go to the Tan θ column (5th column from the right labeled Tan θ on the bottom of the chart).

To find the Tan of an angle let us look at the chart below:

Deg	Radian	Sin θ	Cos θ	Tan θ	Cot θ	Sec θ	Csc θ		
22.5	0.3927	0.3827	0.9239	0.4142	2.4142	1.0824	2.6131	1.1781	67.5
23	0.4014	0.3907	0.9205	0.4245	2.3559	1.0864	2.5593	1.1694	67
23.5	0.4102	0.3987	0.9171	0.4348	2.2998	1.0904	2.5078	1.1606	66.5
24	0.4189	0.4067	0.9135	0.4452	2.2460	1.0946	2.4586	1.1519	66
24.5	0.4276	0.4147	0.9100	0.4557	2.1943	1.0989	2.4114	1.1432	65.5
25	0.4363	0.4226	0.9063	0.4663	2.1445	1.1034	2.3662	1.1345	65
25.5	0.4451	0.4305	0.9026	0.4770	2.0965	1.1079	2.3228	1.1257	64.5
26	0.4538	0.4384	0.8988	0.4877	2.0503	1.1126	2.2812	1.1170	64
26.5	0.4625	0.4462	0.8949	0.4986	2.0057	1.1174	2.2412	1.1083	63.5
27	0.4712	0.4540	0.8910	0.5095	1.9626	1.1223	2.2027	1.0996	63
27.5	0.4800	0.4617	0.8870	0.5206	1.9210	1.1274	2.1657	1.0908	62.5
28	0.4887	0.4695	0.8829	0.5317	1.8807	1.1326	2.1301	1.0821	62
28.5	0.4974	0.4772	0.8788	0.5430	1.8418	1.1379	2.0957	1.0734	61.5
29	0.5061	0.4848	0.8746	0.5543	1.8040	1.1434	2.0627	1.0647	61
29.5	0.5149	0.4924	0.8704	0.5658	1.7675	1.1490	2.0308	1.0559	60.5
30	0.5236	0.5000	0.8660	0.5774	1.7321	1.1547	2.0000	1.0472	60
30.5	0.5323	0.5075	0.8616	0.5890	1.6977	1.1606	1.9703	1.0385	59.5
31	0.5411	0.5150	0.8572	0.6009	1.6643	1.1666	1.9416	1.0297	59
31.5	0.5498	0.5225	0.8526	0.6128	1.6319	1.1728	1.9139	1.0210	58.5
32	0.5585	0.5299	0.8480	0.6249	1.6003	1.1792	1.8871	1.0123	58
32.5	0.5672	0.5373	0.8434	0.6371	1.5697	1.1857	1.8612	1.0036	57.5
33	0.5760	0.5446	0.8387	0.6494	1.5399	1.1924	1.8361	0.9948	57
33.5	0.5847	0.5519	0.8339	0.6619	1.5108	1.1992	1.8118	0.9861	56.5
34	0.5934	0.5592	0.8290	0.6745	1.4826	1.2062	1.7883	0.9774	56
34.5	0.6021	0.5664	0.8241	0.6873	1.4550	1.2134	1.7655	0.9687	55.5
35	0.6109	0.5736	0.8192	0.7002	1.4281	1.2208	1.7434	0.9599	55
35.5	0.6196	0.5807	0.8141	0.7133	1.4019	1.2283	1.7221	0.9512	54.5
36	0.6283	0.5878	0.8090	0.7265	1.3764	1.2361	1.7013	0.9425	54
36.5	0.6370	0.5948	0.8039	0.7400	1.3514	1.2440	1.6812	0.9338	53.5
37	0.6458	0.6018	0.7986	0.7536	1.3270	1.2521	1.6616	0.9250	53
37.5	0.6545	0.6088	0.7934	0.7673	1.3032	1.2605	1.6427	0.9163	52.5
38	0.6632	0.6157	0.7880	0.7813	1.2799	1.2690	1.6243	0.9076	52
38.5	0.6720	0.6225	0.7826	0.7954	1.2572	1.2778	1.6064	0.8988	51.5
39	0.6807	0.6293	0.7771	0.8098	1.2349	1.2868	1.5890	0.8901	51
39.5	0.6894	0.6361	0.7716	0.8243	1.2131	1.2960	1.5721	0.8814	50.5
40	0.6981	0.6428	0.7660	0.8391	1.1918	1.3054	1.5557	0.8727	50
40.5	0.7069	0.6494	0.7604	0.8541	1.1708	1.3151	1.5398	0.8639	49.5
41	0.7156	0.6561	0.7547	0.8693	1.1504	1.3250	1.5243	0.8552	49
41.5	0.7243	0.6626	0.7490	0.8847	1.1303	1.3352	1.5092	0.8465	48.5
42	0.7330	0.6691	0.7431	0.9004	1.1106	1.3456	1.4945	0.8378	48
42.5	0.7418	0.6756	0.7373	0.9163	1.0913	1.3563	1.4802	0.8290	47.5
43	0.7505	0.6820	0.7314	0.9325	1.0724	1.3673	1.4663	0.8203	47
43.5	0.7592	0.6884	0.7254	0.9490	1.0538	1.3786	1.4527	0.8116	46.5
44	0.7679	0.6947	0.7193	0.9657	1.0355	1.3902	1.4396	0.8029	46
44.5	0.7767	0.7009	0.7133	0.9827	1.0176	1.4020	1.4267	0.7941	45.5
45	0.7854	0.7071	0.7071	1.0000	1.0000	1.4142	1.4142	0.7854	45
		Cos θ	Sin θ	Cot θ	Tan θ	Csc θ	Sec θ	Radian	Deg

Take Out Exercises

Now let's try some problems to find **take outs** by using the Tan θ and radius. Use the chart of page 8 to find **Tan**. Again, the formula for **take out** is:*

$$\textbf{take out} = \textbf{Tan}\ \frac{\theta}{\mathbf{2}} \times \textbf{radius of the ell}$$

Examples

1. Find the **take out** when the angle of the Tan is 35° and the radius is 24".

$$\textbf{take out} = \textbf{Tan}\ \frac{\theta}{\mathbf{2}} \times \textbf{radius of the ell}$$

$$\textbf{take out} = \text{Tan}\ \frac{55°}{2} \times 12"$$

$$\textbf{take out} = \text{Tan } 27.5° \times 12"$$

$$\textbf{take out} = 0.5206 \times 12"$$

$$\textbf{take out} = 6.2472"$$

2. Find the **take out** when the angle of the Tan is 75° and the radius is 10".

$$\textbf{take out} = \textbf{Tan}\ \frac{\theta}{\mathbf{2}} \times \textbf{radius of the ell}$$

$$\textbf{take out} = \text{Tan}\ \frac{75°}{2} \times 10"$$

$$\textbf{take out} = \text{Tan } 37.5° \times 10"$$

$$\textbf{take out} = 0.7673 \times 10"$$

$$\textbf{take out} = 7.673"$$

***Please note:** Do not use $\frac{\text{Tan } \theta}{2}$ as a substitute for Tan $\frac{\theta}{2}$. In other words, don't take the tangent of the whole angle and divide it by 2. Divide the angle by 2, and then get the tangent of the half angle. It makes a difference.

Exercises

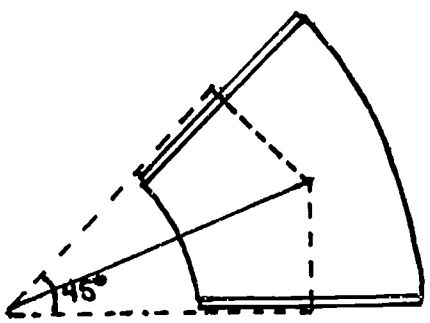
1. Find the **take out** when the angle of the Tan is 80° and the radius is 25".

take out	=	**Tan $\frac{\theta}{2}$**	**x**	**radius of the ell**
take out	=	Tan $\frac{80°}{2}$	x	25"
take out	=	Tan ?°	x	25"
take out	=	0.?	x	25"
take out	=	?"		

2. Find the **take out** for a 45° ell with an 8" radius.

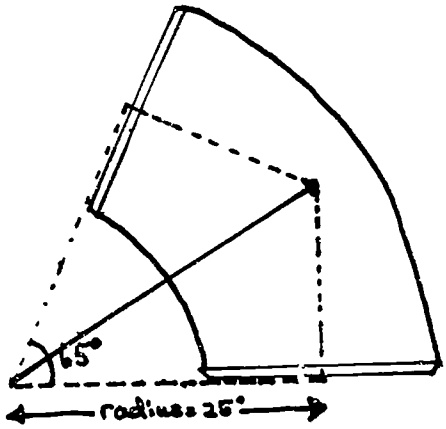
take out	=	**Tan $\frac{\theta}{2}$**	**x**	**radius of the ell**
take out	=	Tan $\frac{45°}{2}$	x	8"
take out	=	Tan ?°	x	8"
take out	=	0.?	x	8"
take out	=	?"		

3. Find the **take out** for the elbow shown below:



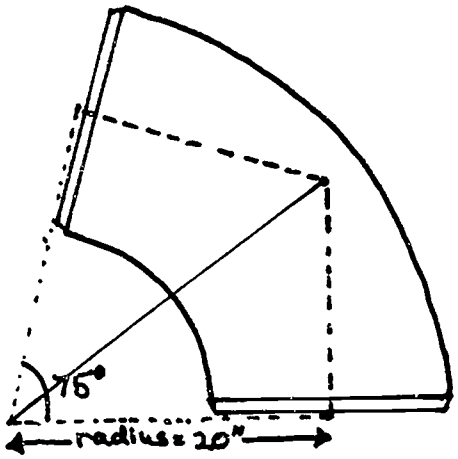
take out	=	**Tan $\frac{\theta}{2}$**	**x**	**radius**
take out	=	Tan $\frac{45°}{2}$	x	1"
take out	=	Tan ?°	x	1"
take out	=	?	x	1"
take out	=	?"		

4. Find the **take out** for the elbow shown below:



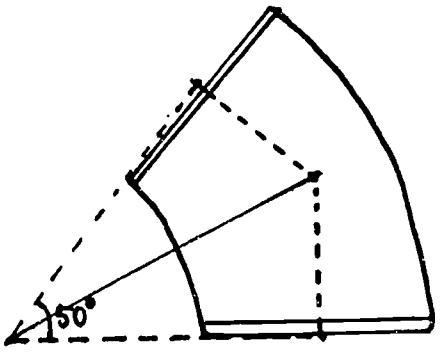
take out	=	**Tan $\frac{\theta}{2}$**	**x**	**radius**
take out	=	Tan $\frac{65°}{2}$	x	25"
take out	=	Tan ?°	x	25"
take out	=	?	x	25"
take out	=	?"		

5. Find the **take out** for the elbow shown below:



take out	=	**Tan $\frac{\theta}{2}$**	**x**	**radius**
take out	=	Tan $\frac{?°}{2}$	x	?"
take out	=	Tan ?°	x	?"
take out	=	?	x	?"
take out	=	?"		

6. Find the **take out** for the elbow shown below:



take out	=	**Tan $\frac{\theta}{2}$**	**x**	**radius**
take out	=	Tan $\frac{?°}{2}$	x	?"
take out	=	Tan ?°	x	?"
take out	=	?	x	?"
take out	=	?"		

If you would more practice on finding takeouts, go to the TDC notebook entitled **Reading and Solving Pipefitter Takeout Problems.**

Answers to Exercises

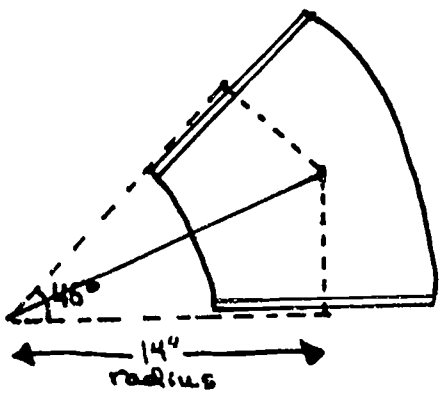
1. Find the **take out** when the angle of the Tan is 80° and the radius is 25".

take out	=	**Tan $\frac{\theta}{2}$**	**x**	**radius of the ell**
take out	=	Tan $\frac{80°}{2}$	x	25"
take out	=	Tan 40°	x	25"
take out	=	0.8391	x	25"
take out	=	20.9775"		

2. Find the **take out** for a 45° ell with an 8" radius.

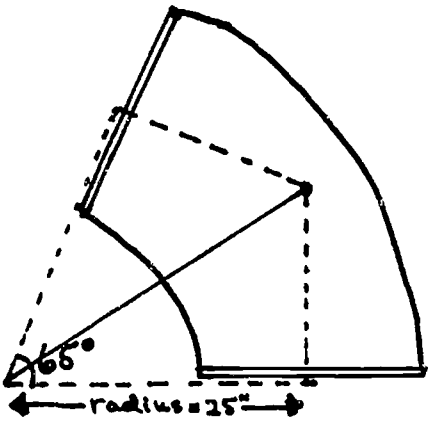
take out	=	**Tan $\frac{\theta}{2}$**	**x**	**radius of the ell**
take out	=	Tan $\frac{45°}{2}$	x	8"
take out	=	Tan 22.5°	x	8"
take out	=	0.4142	x	8"
take out	=	3.3136"		

3. Find the **take out** for the elbow shown below:



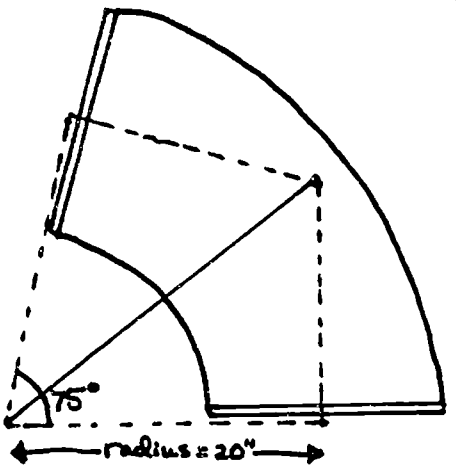
take out	=	**Tan $\frac{\theta}{2}$**	**x**	**radius**
take out	=	Tan $\frac{45°}{2}$	x	14"
take out	=	Tan 22.5°	x	14"
take out	=	0.4142	x	14"
take out	=	5.7988"		

4. Find the **take out** for the elbow shown below:



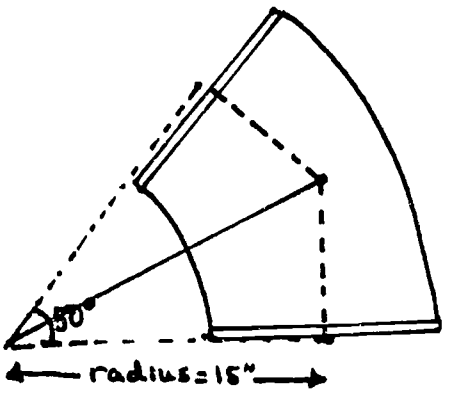
take out	=	**Tan $\frac{\theta}{2}$**	**x**	**radius**
take out	=	Tan $\frac{65°}{2}$	x	25"
take out	=	Tan 32.5°	x	25"
take out	=	0.6371	x	25"
take out	=	15.9275"		

5. Find the **take out** for the elbow shown below:



take out	=	**Tan $\frac{\theta}{2}$**	**x**	**radius**
take out	=	Tan $\frac{75°}{2}$	x	20"
take out	=	Tan 37.5°	x	20"
take out	=	0.7673	x	20"
take out	=	15.346"		

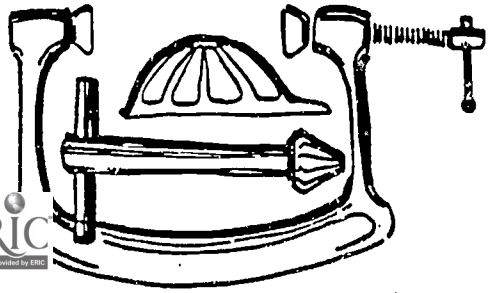
6. Find the **take out** for the elbow shown below:



take out	=	**Tan $\frac{\theta}{2}$**	**x**	**radius**
take out	=	Tan $\frac{50°}{2}$	x	15"
take out	=	Tan 25°	x	15"
take out	=	0.4663	x	15"
take out	=	6.9945"		

TECHNICAL DEVELOPMENT CENTER

Reading & Solving
Pipefitter Takeout Problems



Associated Builders & Contractors, Inc.
EBR Adult & Continuing Education

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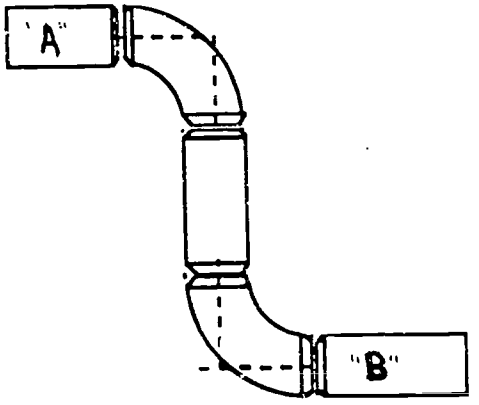
Finding Take Outs

Take Out is the length of pipe the elbow (ell) adds to a pipe offset. It is the distance an ell extends the center line of a run of pipe past the end of the pipe.

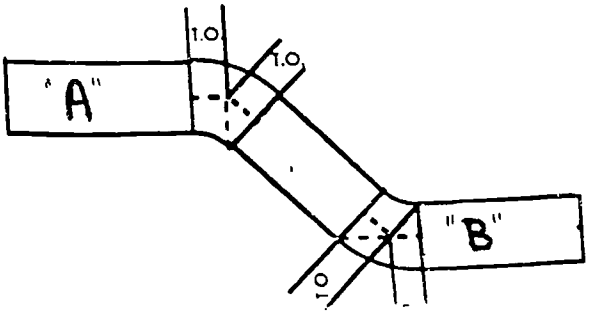
To connect Pipe "A" to Pipe "B" in the example below, you first need to find the "**take out**" or how much length the elbows (ells) add in order to connect these pipes together.

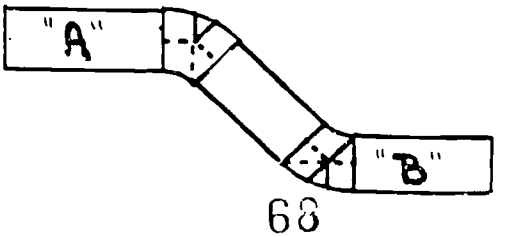
ex.



T.O. = Take Out

Below are some examples of **take outs**. Look at how much length a **take out** adds to a run of pipe. Different angles of ell have different **take outs**.



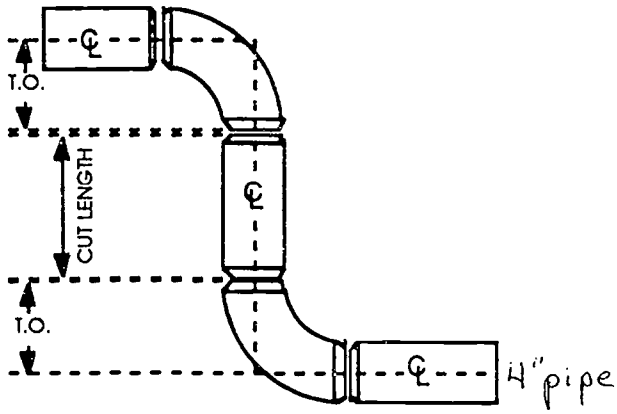


Finding 90° Ell Take Outs

In order to find the length of pipe needed to connect two pipes, we must first identify how much of the offset is taken up by the ells. This distance is called **take out** and is equal to 1½ times the nominal pipe size in a 90° ell.[1] The radius and **take out** of a 90° ell are equal.

ex. pipe size = 4"

radius of a 4" 90°ell = 4" x 1½ = 6"



Exercises

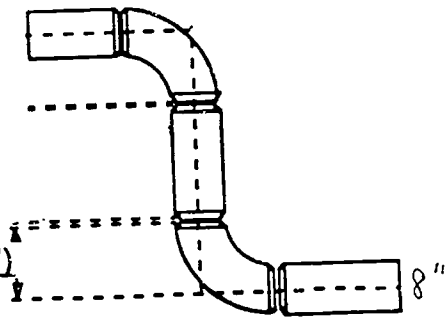
1. When using a 90° butt weld ell, if the pipe size is 8", what is the **take out**? (Remember, the **Take Out** of a fitting is the distance that a fitting extends the center line of a run of pipe past the end of the pipe.)

   ex. Nominal Pipe Size = 8"

   Radius of an 8" pipe = 1½ x 8" = 12"

   If radius = take out

   What is take out of a 90° butt weld of an 8" pipe? = (12")



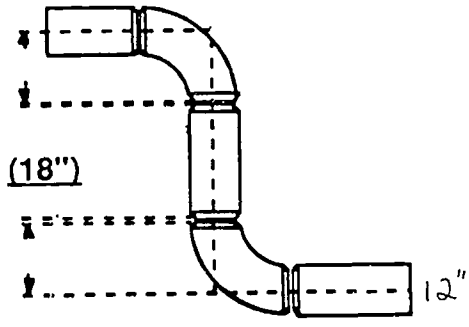
2. When using a 90° butt weld ell, if the pipe size is 12", what is the **take out**?

   ex. Nominal Pipe Size = 12"

   Radius of an 12" pipe = 1½ x 12" = 18"

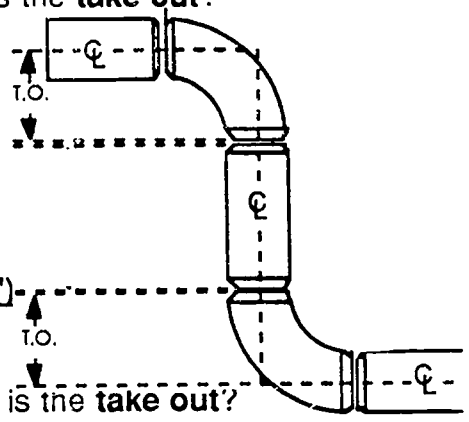
   If radius = **take out**

   What is **take out** of a 90° butt weld of an 12" pipe? (18")



[1]Nominal pipe size (NPS) is the size we call the pipe, not to be confused with the actual size of the pipe.

3. When using a 90° butt weld ell, if the pipe size is 3", what is the **take out**?



ex. Nominal Pipe Size = 3"

Radius of an 3" pipe = 1½ x 3"

If radius = **take out**

What is the **take out** of a 90° butt weld of an 3" pipe? **(4½")**

4. When using a 90° butt weld ell, if the pipe size is 14", what is the **take out**?

ex. Nominal Pipe Size = 14"

Radius of an 14" pipe = 1½ x 14"

If radius = **take out**

What is **take out** of a 90° butt weld of an 14" pipe? **(21")**

5. In a 90° butt weld ell, what is the **take out** if you have a factory made 10" pipe?

ex. Nominal Pipe Size = 10"

Radius =

take out =

6. In a 90° butt weld ell, what is the **take out** if you make a 24" pipe?

ex. Pipe Size = 24"

Radius =

take out =

7. In a 90° butt weld ell, what is the take out if you have a factory made 6" pipe?

ex. Nominal Pipe Size = 6"

Radius =

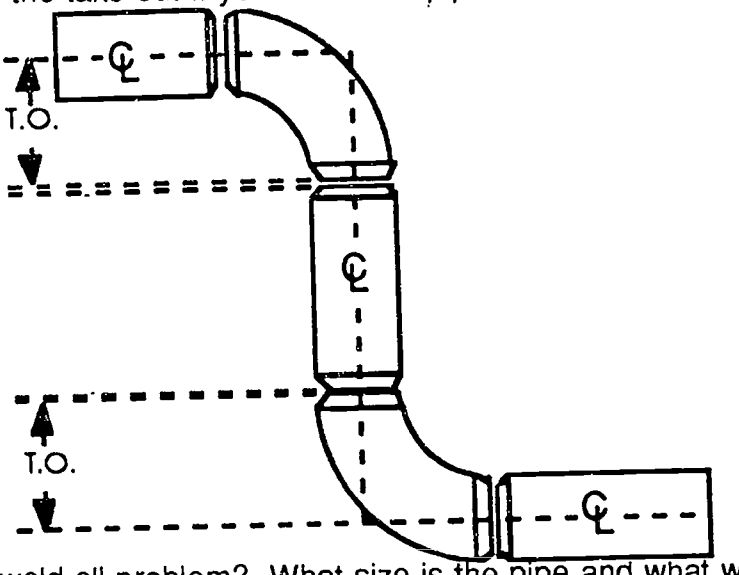
take out =

8. In a 90° butt weld ell, what is the take out if you have a 3" pipe?

Ex. Pipe Size = 3"

Radius =

take out =



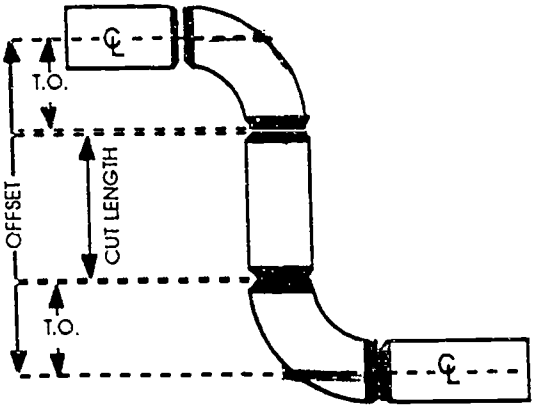
Answers
5. **take out** = 15"
6. **take out** = 36"
7. **take out** = 9"
8. **take out** = 4½"

9. Can you think up a 90° butt weld ell problem? What size is the pipe and what will the take out be?

Ex. Pipe Size = ?"

Radius =

take out =



Now that you know how to find a **take out** for a 90° ell, it is time to use a formula you can use to find the **take out** for all ells (including 90°, 45°, 30°, etc., ells).

The formula for **take out** is:

$$\textbf{take out} = \text{Tan}\frac{\theta}{2} \times \textbf{radius of the ell}$$

(To be successful in finding **take outs** and to use the **take out** formula we recommend you **use a calculator** to work the multiplication of decimals.)

Let us first solve how to find a tangent of an angle (**Tan** θ). To do so, we must use a trigonometry chart (found on the next page) that includes **Tan** θ. Read the degrees of the angle in your problem by looking at the left column marked "**Deg**" if the angle is between 22.5° and 45°. If the degree of the angle is between 45° and 67.5° then find it in the far right column with the word "**Deg**" at the bottom of the column.

To find the Tan of an angle let us look at the chart below:

Deg	Radian	Sin θ	Cos θ	Tan θ	Cot θ	Sec θ	Csc θ		
22.5	0.3927	0.3827	0.9239	0.4142	2.4142	1.0824	2.6131	1.1781	67.5
23	0.4014	0.3907	0.9205	0.4245	2.3559	1.0864	2.5593	1.1694	67
23.5	0.4102	0.3987	0.9171	0.4348	2.2998	1.0904	2.5078	1.1606	66.5
24	0.4189	0.4067	0.9135	0.4452	2.2460	1.0946	2.4586	1.1519	66
24.5	0.4276	0.4147	0.9100	0.4557	2.1943	1.0989	2.4114	1.1432	65.5
25	0.4363	0.4226	0.9063	0.4663	2.1445	1.1034	2.3662	1.1345	65
25.5	0.4451	0.4305	0.9026	0.4770	2.0965	1.1079	2.3228	1.1257	64.5
26	0.4538	0.4384	0.8988	0.4877	2.0503	1.1126	2.2812	1.1170	64
26.5	0.4625	0.4462	0.8949	0.4986	2.0057	1.1174	2.2412	1.1083	63.5
27	0.4712	0.4540	0.8910	0.5095	1.9626	1.1223	2.2027	1.0996	63
27.5	0.4800	0.4617	0.8870	0.5206	1.9210	1.1274	2.1657	1.0908	62.5
28	0.4887	0.4695	0.8829	0.5317	1.8807	1.1326	2.1301	1.0821	62
28.5	0.4974	0.4772	0.8788	0.5430	1.8418	1.1379	2.0957	1.0734	61.5
29	0.5061	0.4848	0.8746	0.5543	1.8040	1.1434	2.0627	1.0647	61
29.5	0.5149	0.4924	0.8704	0.5658	1.7675	1.1490	2.0308	1.0559	60.5
30	0.5236	0.5000	0.8660	0.5774	1.7321	1.1547	2.0000	1.0472	60
30.5	0.5323	0.5075	0.8616	0.5890	1.6977	1.1606	1.9703	1.0385	59.5
31	0.5411	0.5150	0.8572	0.6009	1.6643	1.1666	1.9416	1.0297	59
31.5	0.5498	0.5225	0.8526	0.6128	1.6319	1.1728	1.9139	1.0210	58.5
32	0.5585	0.5299	0.8480	0.6249	1.6003	1.1792	1.8871	1.0123	58
32.5	0.5672	0.5373	0.8434	0.6371	1.5697	1.1857	1.8612	1.0036	57.5
33	0.5760	0.5446	0.8387	0.6494	1.5399	1.1924	1.8361	0.9948	57
33.5	0.5847	0.5519	0.8339	0.6619	1.5108	1.1992	1.8118	0.9861	56.5
34	0.5934	0.5592	0.8290	0.6745	1.4826	1.2062	1.7883	0.9774	56
34.5	0.6021	0.5664	0.8241	0.6873	1.4550	1.2134	1.7655	0.9687	55.5
35	0.6109	0.5736	0.8192	0.7002	1.4281	1.2208	1.7434	0.9599	55
35.5	0.6196	0.5807	0.8141	0.7133	1.4019	1.2283	1.7221	0.9512	54.5
36	0.6283	0.5878	0.8090	0.7265	1.3764	1.2361	1.7013	0.9425	54
36.5	0.6370	0.5948	0.8039	0.7400	1.3514	1.2440	1.6812	0.9338	53.5
37	0.6458	0.6018	0.7986	0.7536	1.3270	1.2521	1.6616	0.9250	53
37.5	0.6545	0.6088	0.7934	0.7673	1.3032	1.2605	1.6427	0.9163	52.5
38	0.6632	0.6157	0.7880	0.7813	1.2799	1.2690	1.6243	0.9076	52
38.5	0.6720	0.6225	0.7826	0.7954	1.2572	1.2778	1.6064	0.8988	51.5
39	0.6807	0.6293	0.7771	0.8098	1.2349	1.2868	1.5890	0.8901	51
39.5	0.6894	0.6361	0.7716	0.8243	1.2131	1.2960	1.5721	0.8814	50.5
40	0.6981	0.6428	0.7660	0.8391	1.1918	1.3054	1.5557	0.8727	50
40.5	0.7069	0.6494	0.7604	0.8541	1.1708	1.3151	1.5398	0.8639	49.5
41	0.7156	0.6561	0.7547	0.8693	1.1504	1.3250	1.5243	0.8552	49
41.5	0.7243	0.6626	0.7490	0.8847	1.1303	1.3352	1.5092	0.8465	48.5
42	0.7330	0.6691	0.7431	0.9004	1.1106	1.3456	1.4945	0.8378	48
42.5	0.7418	0.6756	0.7373	0.9163	1.0913	1.3563	1.4802	0.8290	47.5
43	0.7505	0.6820	0.7314	0.9325	1.0724	1.3673	1.4663	0.8203	47
43.5	0.7592	0.6884	0.7254	0.9490	1.0538	1.3786	1.4527	0.8116	46.5
44	0.7679	0.6947	0.7193	0.9657	1.0355	1.3902	1.4396	0.8029	46
44.5	0.7767	0.7009	0.7133	0.9827	1.0176	1.4020	1.4267	0.7941	45.5
45	0.7854	0.7071	0.7071	1.0000	1.0000	1.4142	1.4142	0.7854	45
		Cos θ	Sin θ	Cot θ	Tan θ	Csc θ	Sec θ	Radian	Deg

Find the degree of the angle and then look under that TAN θ.

If the degree of the angle is less than 45°:

find the degree listed in the far left column marked "Deg" then find its Tan θ (5th column from left).

If the degree is greater than 45°:

read the degree in the far right column then go to the Tan θ column (5th column from the right labeled Tan θ on the bottom of the chart).

Here are three correct answers from the chart above.

45° Tan is 1.0000
22.5° Tan is 0.4142
67.5° Tan is 2.4142

Find the Tangents (Tan θ) for the following angles by using the chart on the page before:

1. 37.5° Tan is _____

2. 43.5° Tan is _____

3. 48° Tan is _____

4. 57.5° Tan is _____

5. 65.5° Tan is _____

Make up your own problems:

6.

7.

8.

Answers:
1. 0.7673
2. 0.9490
3. 1.1106
4. 1.5697
5. 2.1943

Now let's try some problems that find **take outs** and by using the Tan θ and radius. The formula for **take out** is:

$$\textbf{take out} = \textbf{Tan } \frac{\theta}{2} \textbf{ x radius of the ell}$$

Please note: Do not use $\frac{\text{Tan } \theta}{2}$ as a substitute for Tan $\frac{\theta}{2}$. In other words, don't take the tangent of the whole angle and divide it by 2. Divide the angle by 2, and then get the tangent of the half angle. It makes a difference.

Exercises

1. Find the **take out** when the angle of the Tan is 45° and the radius is 24".

$$\textbf{take out} = \textbf{Tan } \frac{\theta}{2} \textbf{ x radius of the ell}$$

$$\textbf{take out} = \text{Tan } \frac{45°}{2} \text{ x } 24"$$

$$\textbf{take out} = \text{Tan } 22.5° \text{ x } 24"$$

$$\textbf{take out} = 0.4142 \text{ x } 24"$$

$$\textbf{take out} = 9.94"$$

2. Find the **take out** when the angle of the Tan is 60° and the radius is 8'.

$$\textbf{take out} = \textbf{Tan } \frac{\theta}{2} \textbf{ x radius of the ell}$$

$$\textbf{take out} = \text{Tan } \frac{60°}{2} \text{ x } 8"$$

$$\textbf{take out} = \text{Tan } 30° \text{ x } 8"$$

$$\textbf{take out} = 0.5774 \text{ x } 8"$$

$$\textbf{take out} = 4.6192"$$

3. Find the **take out** when the angle of the Tan is 75° and the radius is 36".

take out	=	**Tan $\frac{\theta}{2}$**	**x**	**radius of the ell**
take out	=	Tan $\frac{75°}{2}$	x	36"
take out	=	Tan 37.5°	x	36"
take out	=	0.7673	x	36"
take out	=	27.6228"		

4. Find the **take out** for a 6" 45° ell".

take out	=	**Tan $\frac{\theta}{2}$**	**x**	**radius of the ell**

(Remember: the radius of a 6" ell is 1½ x NPS or 1½ x 6")

take out	=	Tan $\frac{45°}{2}$	x	9"
take out	=	Tan 22.5°	x	9"
take out	=	0.4142	x	9"
take out	=	3.7278"		

5. Find the **take out** for a 16" 50° ell".

take out	=	**Tan $\frac{\theta}{2}$**	**x**	**radius of the ell**

(Remember: the radius of a 16" ell is 1½ x NPS or 1½ x 16")

take out	=	Tan $\frac{50°}{2}$	x	24"
take out	=	Tan 25°	x	24"
take out	=	0.4663	x	24"
take out	=	11.1912"		

6. Find the **take out** for a 10" 45° ell".

take out = **Tan** $\frac{\theta}{2}$ **x** **radius of the ell**

(Remember: the radius of a 10" ell is 1½ x NPS)

take out = Tan $\frac{45°}{2}$ x _____"

take out = Tan _____° x _____"

take out = _____ x _____"

take out = _____"

7. Find the **take out** for a 18" 70° ell".

take out = **Tan** $\frac{\theta}{2}$ **x** **radius of the ell**

(Remember: the radius of an 18" ell is 1½ x NPS)

take out = Tan $\frac{70°}{2}$ x _____"

take out = Tan _____° x _____"

take out = _____ x _____"

take out = _____"

8. Find the **take out** for a 48" 68° ell".

take out = **Tan** $\frac{\theta}{2}$ **x** **radius of the ell**

take out = Tan $\frac{68°}{2}$ x _____"

take out = Tan _____° x _____"

take out = _____ x _____"

take out = _____"

Answers

6. Find the **take out** for a 10" 45° ell".

take out = **Tan $\frac{\theta}{2}$** x **radius of the ell**

(Remember: the radius of a 10" ell is 1½ x NPS)

take out = Tan $\frac{45°}{2}$ x 15"

take out = Tan 22.5° x 15"

take out = 0.4142 x 15"

take out = 6.213"

7. Find the **take out** for a 18" 70° ell".

take out = **Tan $\frac{\theta}{2}$** x **radius of the ell**

(Remember: the radius of an 18" ell is 1½ x NPS)

take out = Tan $\frac{70°}{2}$ x 27"

take out = Tan 35° x 27"

take out = 0.7002 x 27"

take out = 18.9054"

8. Find the **take out** for a 48" 68° ell".

take out = **Tan $\frac{\theta}{2}$** x **radius of the ell**

take out = Tan $\frac{68°}{2}$ x 72"

take out = Tan 34° x 72"

take out = 0.6745 x 72"

take out = 48.5640"

Using The Pipe Fitters Blue Book

Some pipefitters like to use The Pipe Fitters Blue Book by W. V. Graves to help them find the Tan Θ. This book fits into your pocket and is more accurate because it gives you the tangent to the 1/100,000 or one hundred thousandths. Below is a page from the book that shows you all the Tangents for 30°. The column on the far left is the minutes (there are 60 minutes to each degree.) To help you read a Tan Θ from this chart, go to the 4th column from the left labeled, "Tan".

Examples:

Tan 30° = .57735

Tan 30°30 = .58904

Tan 30°40 = .59297

Tan 30°59 = .60046

30°

M	Sine	Cosine	Tan.	Cotan.	Secant	Cosec.	M
0	.50000	.86603	.57735	1.7320	1.1547	2.0000	60
1	.50025	.86588	.57774	.7309	.1549	1.9990	59
2	.50050	.86573	.57813	.7297	.1551	.9980	58
3	.50075	.86559	.57851	.7286	.1553	.9970	57
4	.50101	.86544	.57890	.7274	.1555	.9960	56
5	.50126	.86530	.57929	1.7262	1.1557	1.9950	55
6	.50151	.86515	.57968	.7251	.1559	.9940	54
7	.50176	.86500	.58007	.7239	.1561	.9930	53
8	.50201	.86486	.58046	.7228	.1562	.9920	52
9	.50226	.86471	.58085	.7216	.1564	.9910	51
10	.50252	.86457	.58123	1.7205	1.1566	1.9900	50
11	.50277	.86442	.58162	.7193	.1568	.9890	49
12	.50302	.86427	.58201	.7182	.1570	.9880	48
13	.50327	.86413	.58240	.7170	.1572	.9870	47
14	.50352	.86398	.58279	.7159	.1574	.9860	46
15	.50377	.86383	.58318	1.7147	1.1576	1.9850	45
16	.50402	.86369	.58357	.7136	.1578	.9840	44
17	.50428	.86354	.58396	.7124	.1580	.9830	43
18	.50453	.86339	.58435	.7113	.1582	.9820	42
19	.50478	.86325	.58474	.7101	.1584	.9811	41
20	.50503	.86310	.58513	1.7090	1.1586	1.9801	40
21	.50528	.86295	.58552	.7079	.1588	.9791	39
22	.50553	.86281	.58591	.7067	.1590	.9781	38
23	.50578	.86266	.58630	.7056	.1592	.9771	37
24	.50603	.86251	.58670	.7044	.1594	.9761	36
25	.50628	.86237	.58709	1.7033	1.1596	1.9752	35
26	.50653	.86222	.58748	.7022	.1598	.9742	34
27	.50679	.86207	.58787	.7010	.1600	.9732	33
28	.50704	.86192	.58826	.6999	.1602	.9722	32
29	.50729	.86178	.58865	.6988	.1604	.9713	31
30	.50754	.86163	.58904	1.6977	1.1606	1.9703	30
31	.50779	.86148	.58944	.6965	.1608	.9693	29
32	.50804	.86133	.58983	.6954	.1610	.9683	28
33	.50829	.86118	.59022	.6943	.1612	.9674	27
34	.50854	.86104	.59061	.6931	.1614	.9664	26
35	.50879	.86089	.59100	1.6920	1.1616	1.9654	25
36	.50904	.86074	.59140	.6909	.1618	.9645	24
37	.50929	.86059	.59179	.6898	.1620	.9635	23
38	.50954	.86044	.59218	.6887	.1622	.9625	22
39	.50979	.86030	.59258	.6875	.1624	.9616	21
40	.51004	.86015	.59297	1.6864	1.1626	1.9606	20
41	.51029	.86000	.59336	.6853	.1628	.9596	19
42	.51054	.85985	.59376	.6842	.1630	.9587	18
43	.51079	.85970	.59415	.6831	.1632	.9577	17
44	.51104	.85955	.59454	.6820	.1634	.9568	16
45	.51129	.85941	.59494	1.6808	1.1636	1.9558	15
46	.51154	.85926	.59533	.6797	.1638	.9549	14
47	.51179	.85911	.59572	.6786	.1640	.9539	13
48	.51204	.85896	.59612	.6775	.1642	.9530	12
49	.51229	.85881	.59651	.6764	.1644	.9520	11
50	.51254	.85866	.59691	1.6753	1.1646	1.9510	10
51	.51279	.85851	.59730	.6742	.1648	.9501	9
52	.51304	.85836	.59770	.6731	.1650	.9491	8
53	.51329	.85821	.59809	.6720	.1652	.9482	7
54	.51354	.85806	.59849	.6709	.1654	.9473	6
55	.51379	.85791	.59888	1.6698	1.1656	1.9463	5
56	.51404	.85777	.59928	.6687	.1658	.9454	4
57	.51429	.85762	.59967	.6676	.1660	.9444	3
58	.51454	.85747	.60007	.6665	.1662	.9435	2
59	.51479	.85732	.60046	.6654	.1664	.9425	1
60	.51504	.85717	.60086	1.6643	1.1666	1.9416	0
M	Cosine	Sine	Cotan.	Tan.	Cosec.	Secant	M

59°

160

To read this same page which has a 30° at the top center but for the Tan Θ for 59°, you would read it from the bottom up. The 4th column from the right side labeled at the bottom "Tan" is how you read the tangents for 59°. Find these examples for 59°.

Examples:

Tan 59° = 1.6643

Tan 59°30 = 1.6977

Tan 59°40 = 1.7090

Tan 59°59 = 1.7309

30°

M	Sine	Cosine	Tan	Cotan	Secant	Cosec.	M
0	50000	86603	57735	1.7320	1 1547	2 0000	60
1	50025	86588	57774	7309	1549	1 9990	59
2	50050	86573	57813	7297	1551	9980	58
3	50075	86559	57851	7286	1553	9970	57
4	50101	86544	57890	7274	1555	9960	56
5	50126	86530	57929	1.7262	1 1557	1 9950	55
6	50151	86515	57968	7251	1559	9940	54
7	50176	86500	58007	7239	1561	9930	53
8	50201	86486	58046	7228	1562	9920	52
9	50226	86471	58085	7216	1564	9910	51
10	50252	86457	58123	1.7205	1.1566	1.9900	50
11	50277	86442	58162	7193	1568	9890	49
12	50302	86427	58201	7182	1570	9880	48
13	50327	86413	58240	7170	1572	9870	47
14	50352	86398	58279	7159	1574	9860	46
15	50377	86383	58318	1.7147	1 1576	1 9850	45
16	50402	86369	58357	7136	1578	9840	44
17	50428	86354	58396	7124	1580	9830	43
18	50453	86339	58435	7113	1582	9820	42
19	50478	86325	58474	7101	1584	9811	41
20	50503	86310	58513	1.7090	1 1586	1 9801	40
21	50528	86295	58552	7079	1588	9791	39
22	50553	86281	58591	7067	1590	9781	38
23	50578	86266	58630	7056	1592	9771	37
24	50603	86251	58670	7044	1594	9761	36
25	50628	86237	58709	1.7033	1 1596	1 9752	35
26	50653	86222	58748	7022	1598	9742	34
27	50679	86207	58787	7010	1600	9732	33
28	50704	86192	58826	6999	1602	9722	32
29	50729	86178	58865	6988	1604	9713	31
30	50754	86163	58904	1.6977	1606	1.9703	30
31	50779	86148	58944	6965	1608	9693	29
32	50804	86133	58983	6954	1610	9683	28
33	50829	86118	59022	6943	1612	9674	27
34	50854	86104	59061	6931	1614	9664	26
35	50879	86089	59100	1 6920	1.1616	1.9654	25
36	50904	86074	59140	6909	1618	9645	24
37	50929	86059	59179	6898	1620	9635	23
38	50954	86044	59218	6887	1622	9625	22
39	50979	86030	59258	6875	1624	9616	21
40	51004	86015	59297	1.6864	1.1626	1.9606	20
41	51029	86000	59336	6853	1628	9596	19
42	51054	85985	59376	6842	1630	9587	18
43	51079	85970	59415	6831	1632	9577	17
44	51104	85955	59454	6820	1634	9568	16
45	51129	85941	59494	1.6808	1.1636	1.9558	15
46	51154	85926	59533	6797	1638	9549	14
47	51179	85911	59572	6786	1640	9539	13
48	51204	85896	59612	6775	1642	9530	12
49	51229	85881	59651	6764	1644	9520	11
50	51254	85866	59691	1.6753	1.1646	1.9510	10
51	51279	85851	59730	6742	1648	9501	9
52	51304	85836	59770	6731	1650	9491	8
53	51329	85821	59809	6720	1652	9482	7
54	51354	85806	59849	6709	1654	9473	6
55	51379	85791	59888	1.6698	1 1656	1.9463	5
56	51404	85777	59928	6687	1658	9454	4
57	51429	85762	59967	6676	1660	9444	3
58	51454	85747	60007	6665	1662	9435	2
59	51479	85732	60046	6654	1664	9425	1
60	51504	85717	60086	1.6643	1.1666	1.9416	0
M	Cosine	Sine	Cotan.	Tan.	Cosec.	Secant	M

59°

Exercises

Using the page from The Pipe Fitters Blue Book shown above that shows the Tan for 30° (fourth column from the left read down the page) and the Tan for 59° (fourth column from the right read up the page), do the following word problems.

Example:

Find the **take out** when the angle of the Tan is 60°20. and the radius is 16".

take out = **Tan** $\frac{\theta}{2}$ x **radius of the ell**

take out = Tan $\frac{60°20}{2}$ x 16"

take out = Tan 30°10 x 16"

take out = 0.58123 x 16"

take out = 9.29968"

In the problems below use a copy of page 160 from The Pipefitters Blue Book found on page 12.

1. Find the **take out** when the angle of the Tan is 60°44 and the radius is 28".

take out = **Tan $\frac{\theta}{2}$** x **radius of the ell**

take out = Tan $\frac{60°44}{2}$ x 28"

take out = Tan _____ x 28"

take out = _____ x 28"

take out = _____"

2. Find the **take out** when the angle of the Tan is 60°58 and the radius is 6".

take out = **Tan $\frac{\theta}{2}$** x **radius of the ell**

take out = Tan $\frac{60°58}{2}$ x 6"

take out = Tan _____ x 6"

take out = _____ x 6"

take out = _____"

3. Find the **take out** for a 12" 60°38 ell.

take out = **Tan $\frac{\theta}{2}$** x **radius of the ell**

(Remember: the radius of a 12" ell is 1½ x NPS or 1½ x 12")

take out = Tan $\frac{60°38}{2}$ x 18"

take out = Tan _____ x 18"

take out = _____ x 18"

take out = _____"

4. Find the **take out** for a 60" 60°46 ell.

take out = **Tan $\frac{\theta}{2}$** x **radius of the ell**

(Remember: the radius of a 60" ell is 1½ x NPS or 1½ x 60")

take out = Tan $\frac{60°46}{2}$ x 90"

take out = Tan _____ x 90"

take out = _____ x 90"

take out = _____"

5. Find the **take out** when the angle of the Tan is 60°8 and the radius is 72".

take out = **Tan $\frac{\theta}{2}$** x **radius of the ell**

take out = Tan $\frac{60°8}{2}$ x 72"

take out = Tan _____ x 72"

take out = _____ x 72"

take out = _____"

6. Find the **take out** when the angle of the Tan is 60°12 and the radius is 96".

take out = **Tan $\frac{\theta}{2}$** x **radius of the ell**

take out = Tan $\frac{60°12}{2}$ x 96"

take out = Tan _____ x 96"

take out = _____ x 96"

take out = _____"

Answers

1. Find the **take out** when the angle of the Tan is 60°44 and the radius is 28".

take out	=	**Tan $\frac{\theta}{2}$**	**x**	**radius of the ell**
take out	=	Tan $\frac{60°44}{2}$	x	28"
take out	=	Tan 30°22	x	28"
take out	=	0.58591	x	28"
take out	=	16.40548"		

2. Find the **take out** when the angle of the Tan is 60°58 and the radius is 6".

take out	=	**Tan $\frac{\theta}{2}$**	**x**	**radius of the ell**
take out	=	Tan $\frac{60°58}{2}$	x	6"
take out	=	Tan 30°29	x	6"
take out	=	0.58865	x	6"
take out	=	3.5319"		

3. Find the **take out** for a 12" 60°38 ell.

take out	=	**Tan $\frac{\theta}{2}$**	**x**	**radius of the ell**

(Remember: the radius of a 12" ell is 1½ x NPS or 1½ x 12")

take out	=	Tan $\frac{60°38}{2}$	x	18"
take out	=	Tan 30°14	x	18"
take out	=	0.58279	x	18"
take out	=	10.49022"		

4. Find the **take out** for a 60" 60°46 ell.

take out = **Tan $\frac{\theta}{2}$** x **radius of the ell**

(Remember: the radius of a 60" ell is 1½ x NPS or 1½ x 60")

take out = Tan $\frac{60°46}{2}$ x 90"

take out = Tan 30°23 x 90"

take out = .58630 x 90"

take out = 52.767"

5. Find the **take out** when the angle of the Tan is 60°8 and the radius is 72".

take out = **Tan $\frac{\theta}{2}$** x **radius of the ell**

take out = Tan $\frac{60°8}{2}$ x 72"

take out = Tan 30°4 x 72"

take out = .57890 x 72"

take out = 41.6808"

6. Find the **take out** when the angle of the Tan is 60°12 and the radius is 96".

take out = **Tan $\frac{\theta}{2}$** x **radius of the ell**

take out = Tan $\frac{60°12}{2}$ x 96"

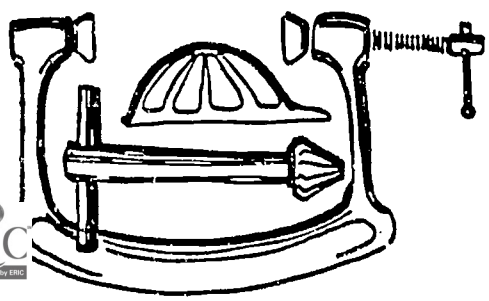
take out = Tan 30°6 x 96"

take out = .57968 x 96"

take out = 55.64928"

TECHNICAL DEVELOPMENT CENTER

Reading & Solving
Basic Pipefitting Problems # 3



Associated Builders & Contractors, Inc.
EBR Adult & Continuing Education

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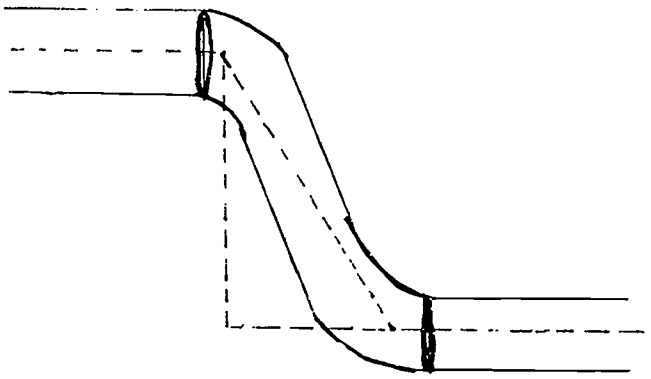
Basic Pipefitting # 3

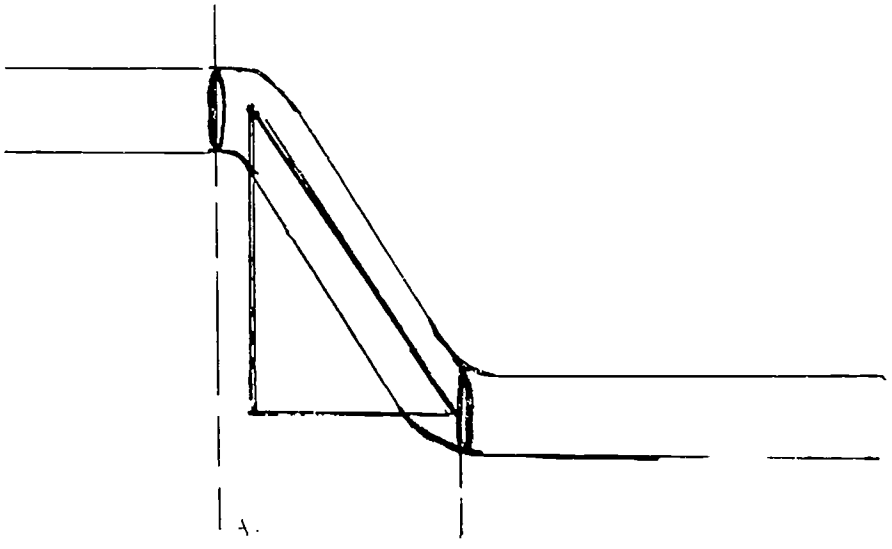
When you need to connect two pipes and you cannot use a 45° or 90° elbow, there are four steps you must add into the steps explained in Reading and Solving Pipefitting Problems # 2. You can use these additional steps in all pipefitter problems if you do not know the angles of the elbows you will use or the length of the offset.

Step 1 Find Tangent

Let us look at the problem below which has two pipes that are at odd angles to each other. In order to connect these pipes we must "see" a triangle between these two pipes.



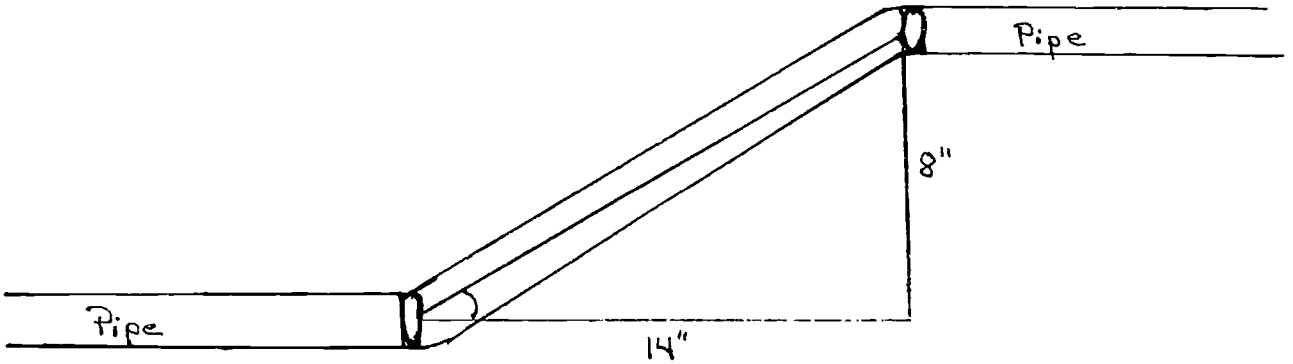
We must find out the length of the two sides of the triangle. One side of the triangle is labeled "a" and the other side of the triangle in labeled "b." You need to measure the length of each of these sides. Be sure when you measure that if you measure from the bottom of one pipe, you measure to the bottom of the other pipe (or the top to the top).



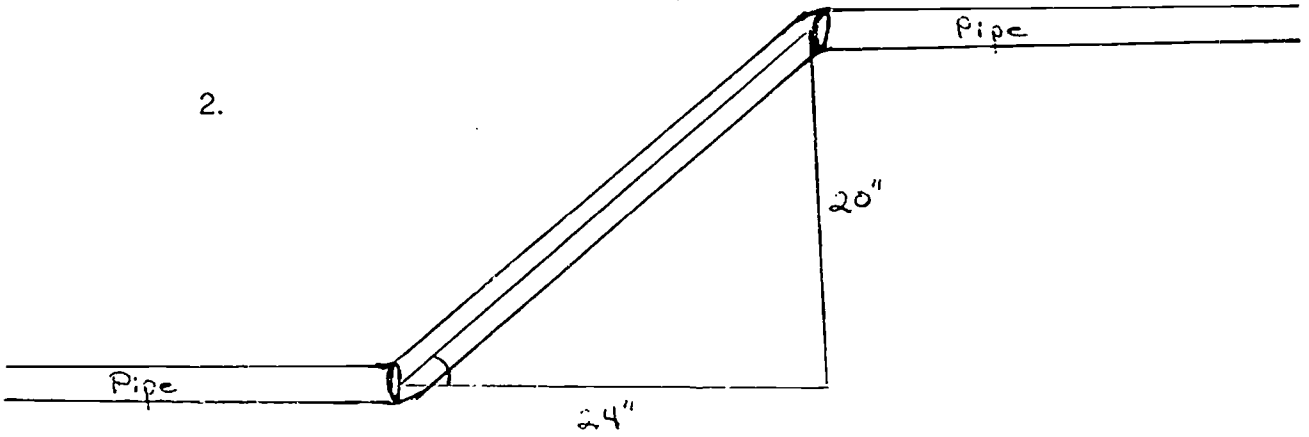
1

What is the "a" and "b" distances between the pipes below?

1.

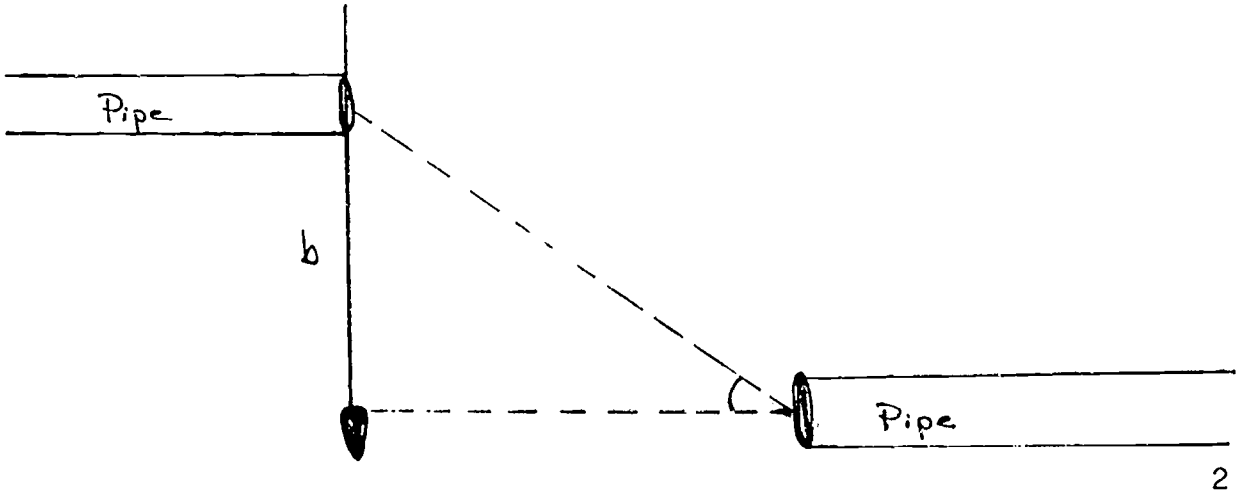


2.



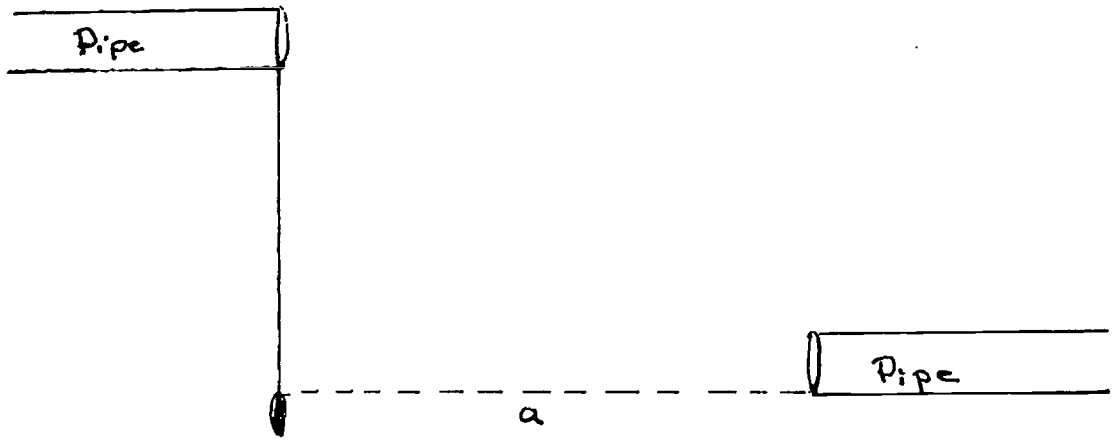
1. a = 14, b = 8;
2. a = 24, b = 20;

When you are in the field, you can drop a plumb line and measure it to find out the length of side "b" (in math, this is called the length of the "opposite" side of an angle).



2

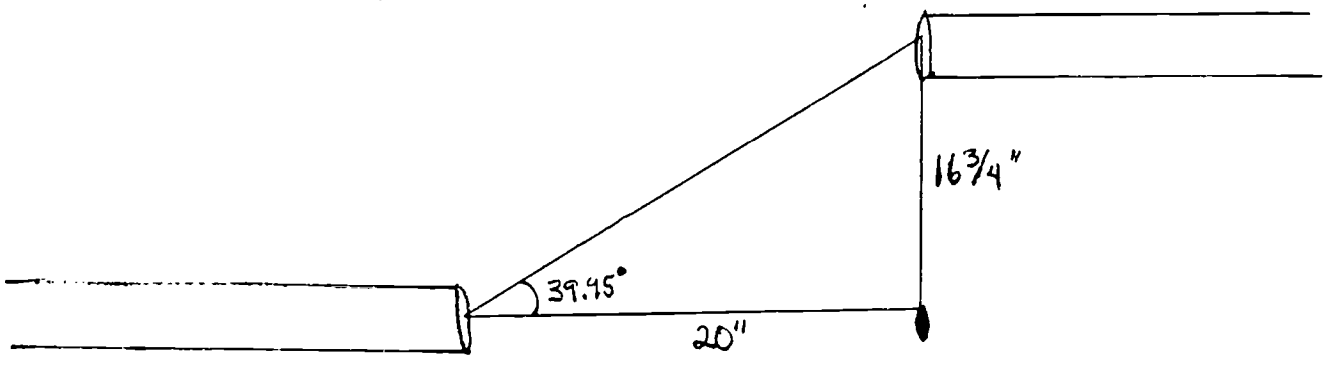
Find the length of side "a" by measuring the distance between from the plumb line to the face of the other pipe (in math, this is called the "adjacent" side of an angle).



Use the lengths of sides "a" and side "b" to find tangent. The formula for tangent is:

$$\text{tangent} = \frac{\text{opposite}}{\text{adjacent}}$$

Here is an example of how to find a tangent in a pipefitter's work.



$$\text{tangent} = \frac{\text{opposite}}{\text{adjacent}} = \frac{16\ 3/4"}{20"} = .8375\ (\text{tan}) = 39.95°$$

= the elbow is a 40° elbow.

Step 2 Find Offset (hypotenuse)

To find the length of the offset (in math this is called the hypothenuse of the triangle) use the formula:

a^2	**+**	**b^2**	**=**	**c^2**
a^2	+	b^2	=	c
16.75^2	+	20^2	=	c
280.5625	+	400	=	c
680.5625			=	c
26.0875"			=	c

Step 3 Find Take Out

Next, you should find the length of the take out. Let's say you have a 6" pipe and the elbow is a 40° elbow (from step 1). Use the take out formula to find the take out.

Take out	**=**	**tan $\frac{\theta}{2}$**	**x**	**radius**
Take out	=	tan 20°	x	9"
Take out	=	0.3640	x	9"
Take out	=	3.276"		

Step 4 Find the cut length of the connecting pipe

The formula for cut length is: Gap is 1/8"

Cut length	**=**	**Run**	**-**	**2 Take outs**	**- 2 Gaps**
Cut length	=	26.0875	-	2(3.276)	- 2(.125)
Cut length	=	26.0875	-	6.552	- .25
Cut length	=	19.205"			

Let's look at some other simple offset problems.

1. You are connecting two 4" pipes. You measure the distances between the two pipes and find side a = 23" and side b = 17." What angle do the elbows need to be and what is the size of the cut length of pipe to connect these pipes?

Step 1 Find tangent

$$\text{tangent} = \frac{\text{opposite}}{\text{adjacent}} = \frac{23}{17} = 1.353 = 53.5°$$

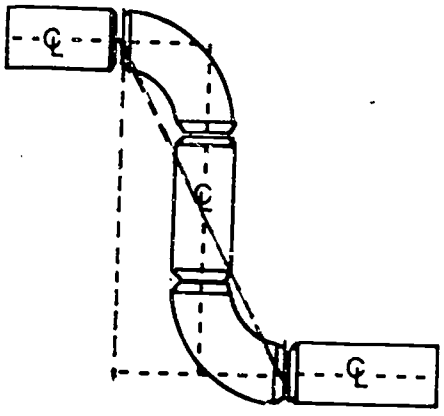
= the elbow is a 53.5° elbow.

Step 2 Find Offset (hypotenuse)

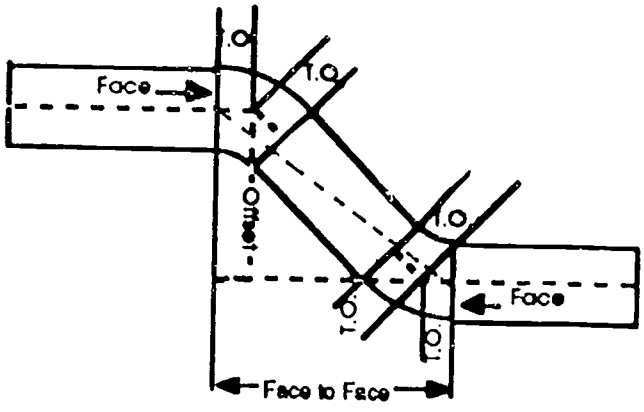
To find the length of the offset (in math this is called the hypothenuse of the triangle) use your calculator with the formula below:

a^2	**+**	**b^2**	**=**	**c^2**
23^2	+	17^2	=	c
529	+	289	=	c
818			=	c
28.6"		=	c	

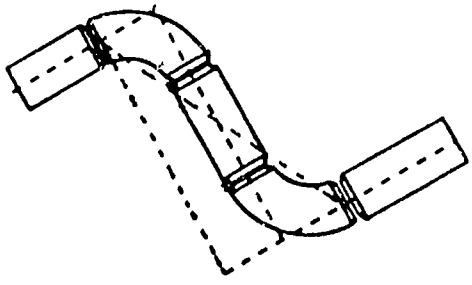
Right angles can also be seen in other pipe problems. See the right triangles in the 90° elbow problem below. Do you see the hypotenuse, adjacent and opposite sides of the triangle?



Can you see the right triangle in the 45° elbow problem below? Do you see the hypotenuse, adjacent and opposite sides of the triangle?



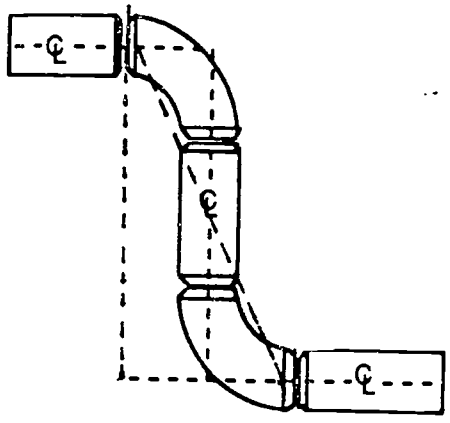
Here is another layout of a 90° pipe problem. Do you see the hypotenuse, adjacent and opposite sides of the triangle?



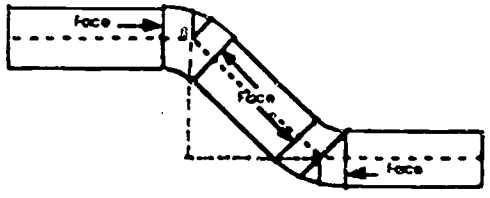
5a.

Test yourself. In the pipe drawings below which side is the triangle's hypotenuse, adjacent side, and opposite side?

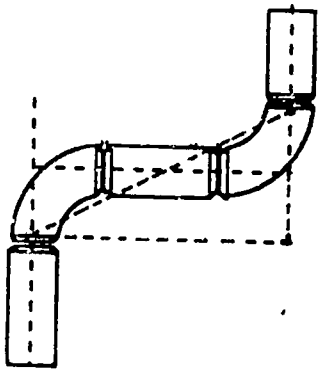
1.



2.



3.



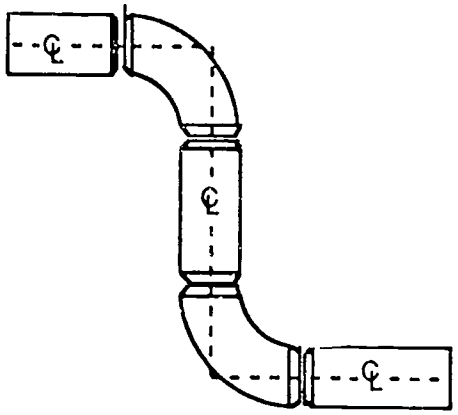
Answers

1a hypotenuse 1b opposite 1c adjacent
2a opposite 2b hypotenuse 2c adjacent
3a adjacent 3b opposite 3c hypotenuse

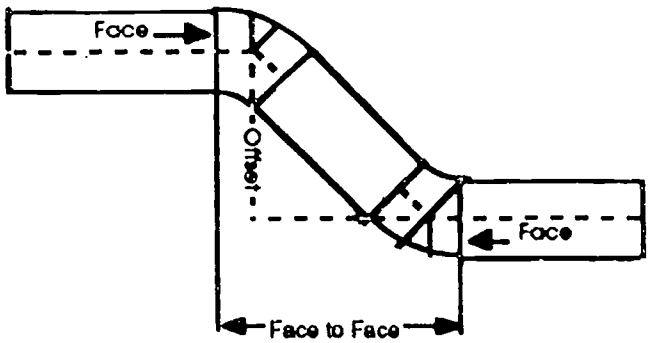
5b.

In the triangles below practice "seeing" the right triangles. When you think you found them, turn the page and compare your answers with the ones drawn on page 5d.

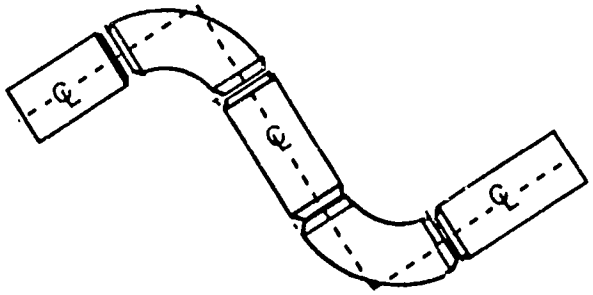
1.



2.



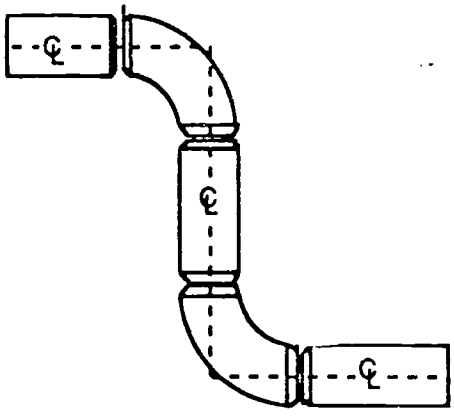
3.



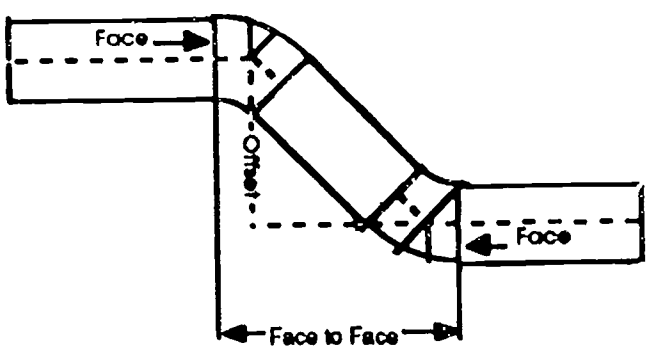
5c.

Here are the triangles found on page 5c with the triangles drawn them. Did you "see" the hypotenuse, adjacent and opposite sides of the triangle?

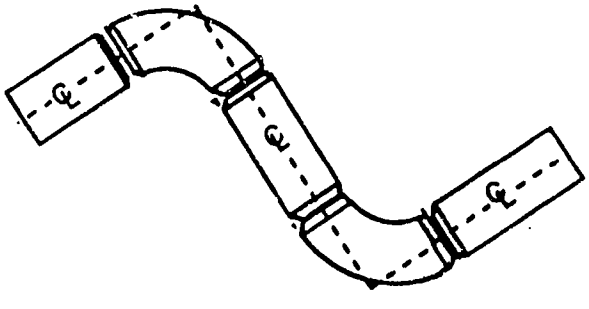
1.



2.



3.



5d.

Step 3 Find Take Out

The take out of a 4" pipe is radius of 4" pipe is 6"

Take out	**=**	**tan $\frac{53.5}{2}$**	**x**	**radius**
Take out	=	tan 26.75°	x	6"
Take out	=	0.4987	x	6"
Take out	=	2.992"		

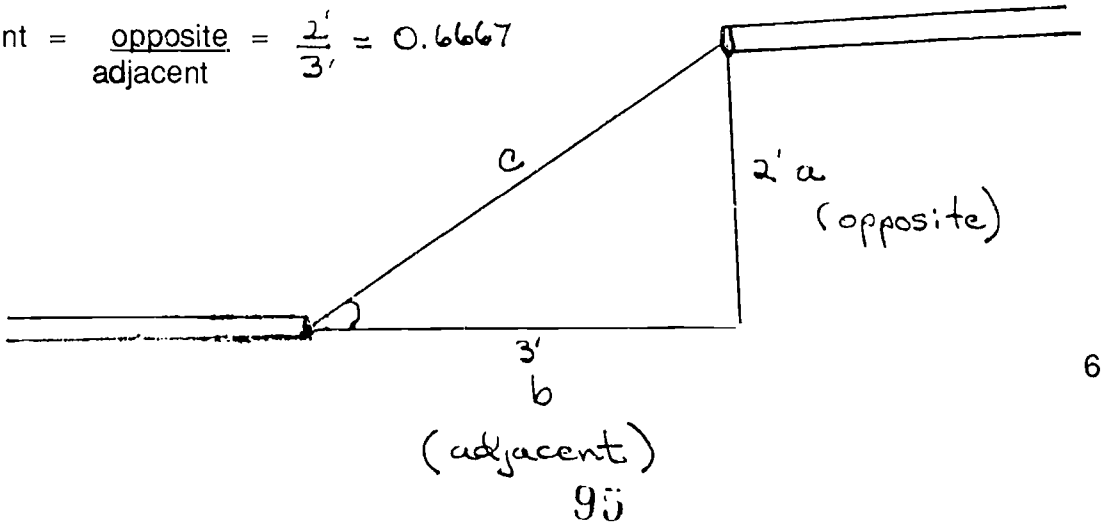
Step 4 Find the cut length of the connecting pipe

The formula for cut length is: Gap is 1/8"

Cut length	**=**	**Run**	**-**	**2 Take outs**	**-**	**2 Gaps**
Cut length	=	28.6"	-	2(2.992)	-	2(.125)
Cut length	=	28.6"	-	5.9844"	-	.25"
Cut length	=	22.366" or 1' 10 3/8"				

2. You are connecting two 6" pipes. You measure the distances between the two pipes and find side a = 2' and side b = 3'. What angle do the elbows need to be and what is the size of the cut length of pipe to connect these pipes?

tangent = $\frac{\text{opposite}}{\text{adjacent}} = \frac{2'}{3'} = 0.6667$



Step 1 **Find tangent**

tangent = $\frac{\text{opposite}}{\text{adjacent}} = \frac{2}{3} = .6667 = 53.5^{\circ}$

Use the Tan chart below to find the Tan

Deg	Radian	Sin θ	Cos θ	Tan θ	Cot θ	Sec θ	Csc θ		
22.5	0.3927	0.3827	0.9239	0.4142	2.4142	1.0824	2.6131	1.1781	67.5
23	0.4014	0.3907	0.9205	0.4245	2.3559	1.0864	2.5593	1.1694	67
23.5	0.4102	0.3987	0.9171	0.4348	2.2998	1.0904	2.5078	1.1606	66.5
24	0.4189	0.4067	0.9135	0.4452	2.2460	1.0946	2.4586	1.1519	66
24.5	0.4276	0.4147	0.9100	0.4557	2.1943	1.0989	2.4114	1.1432	65.5
25	0.4363	0.4226	0.9063	0.4663	2.1445	1.1034	2.3662	1.1345	65
25.5	0.4451	0.4305	0.9026	0.4770	2.0965	1.1079	2.3228	1.1257	64.5
26	0.4538	0.4384	0.8988	0.4877	2.0503	1.1126	2.2812	1.1170	64
26.5	0.4625	0.4462	0.8949	0.4986	2.0057	1.1174	2.2412	1.1083	63.5
27	0.4712	0.4540	0.8910	0.5095	1.9626	1.1223	2.2027	1.0996	63
27.5	0.4800	0.4617	0.8870	0.5206	1.9210	1.1274	2.1657	1.0908	62.5
28	0.4887	0.4695	0.8829	0.5317	1.8807	1.1326	2.1301	1.0821	62
28.5	0.4974	0.4772	0.8788	0.5430	1.8418	1.1379	2.0957	1.0734	61.5
29	0.5061	0.4848	0.8746	0.5543	1.8040	1.1434	2.0627	1.0647	61
29.5	0.5149	0.4924	0.8704	0.5658	1.7675	1.1490	2.0308	1.0559	60.5
30	0.5236	0.5000	0.8660	0.5774	1.7321	1.1547	2.0000	1.0472	60
30.5	0.5323	0.5075	0.8616	0.5890	1.6977	1.1606	1.9703	1.0385	59.5
31	0.5411	0.5150	0.8572	0.6009	1.6643	1.1666	1.9416	1.0297	59
31.5	0.5498	0.5225	0.8526	0.6128	1.6319	1.1728	1.9139	1.0210	58.5
32	0.5585	0.5299	0.8480	0.6249	1.6003	1.1792	1.8871	1.0123	58
32.5	0.5672	0.5373	0.8434	0.6371	1.5697	1.1857	1.8612	1.0036	57.5
33	0.5760	0.5446	0.8387	0.6494	1.5399	1.1924	1.8361	0.9948	57
33.5	0.5847	0.5519	0.8339	0.6619	1.5108	1.1992	1.8118	0.9861	56.5
34	0.5934	0.5592	0.8290	0.6745	1.4826	1.2062	1.7883	0.9774	56
34.5	0.6021	0.5664	0.8241	0.6873	1.4550	1.2134	1.7655	0.9687	55.5
35	0.6109	0.5736	0.8192	0.7002	1.4281	1.2208	1.7434	0.9599	55
35.5	0.6196	0.5807	0.8141	0.7133	1.4019	1.2283	1.7221	0.9512	54.5
36	0.6283	0.5878	0.8090	0.7265	1.3764	1.2361	1.7013	0.9425	54
36.5	0.6370	0.5948	0.8039	0.7400	1.3514	1.2440	1.6812	0.9338	53.5
37	0.6458	0.6018	0.7986	0.7536	1.3270	1.2521	1.6616	0.9250	53
37.5	0.6545	0.6088	0.7934	0.7673	1.3032	1.2605	1.6427	0.9163	52.5
38	0.6632	0.6157	0.7880	0.7813	1.2799	1.2690	1.6243	0.9076	52
38.5	0.6720	0.6225	0.7826	0.7954	1.2572	1.2778	1.6064	0.8988	51.5
39	0.6807	0.6293	0.7771	0.8098	1.2349	1.2868	1.5890	0.8901	51
39.5	0.6894	0.6361	0.7716	0.8243	1.2131	1.2960	1.5721	0.8814	50.5
40	0.6981	0.6428	0.7660	0.8391	1.1918	1.3054	1.5557	0.8727	50
40.5	0.7069	0.6494	0.7604	0.8541	1.1708	1.3151	1.5398	0.8639	49.5
41	0.7156	0.6561	0.7547	0.8693	1.1504	1.3250	1.5243	0.8552	49
41.5	0.7243	0.6626	0.7490	0.8847	1.1303	1.3352	1.5092	0.8465	48.5
42	0.7330	0.6691	0.7431	0.9004	1.1106	1.3456	1.4945	0.8378	48
42.5	0.7418	0.6756	0.7373	0.9163	1.0913	1.3563	1.4802	0.8290	47.5
43	0.7505	0.6820	0.7314	0.9325	1.0724	1.3673	1.4663	0.8203	47
43.5	0.7592	0.6884	0.7254	0.9490	1.0538	1.3786	1.4527	0.8116	46.5
44	0.7679	0.6947	0.7193	0.9657	1.0355	1.3902	1.4396	0.8029	46
44.5	0.7767	0.7009	0.7133	0.9827	1.0176	1.4020	1.4267	0.7941	45.5
45	0.7854	0.7071	0.7071	1.0000	1.0000	1.4142	1.4142	0.7854	45
		Cos θ	Sin θ	Cot θ	Tan θ	Csc θ	Sec θ	Radian	Deg

- the elbow is a 33.5° elbow.

Step 2 Find Offset (hypotenuse)

To find the length of the offset (in math this is called the hypothenuse of the triangle) use your calculator with the formula below and change to inches (1" = 12"):

a^2	+	b^2	=	c^2
24^2	+	36^2	=	c
_____	+	_____	=	c
_____	+	_____	=	c
_____			=	c

Step 3 Find Take Out

The take out formula for a 6" pipe is: radius of 6" pipe is 9"

Take out	=	**tan $\frac{33.5°}{2}$**	**x**	**radius**
Take out	=	tan 16.75°	x	9"

(Use the chart on the page before to find the tan of 16.75°)

Take out	=	_____	x	9"
Take out	=	_____"		

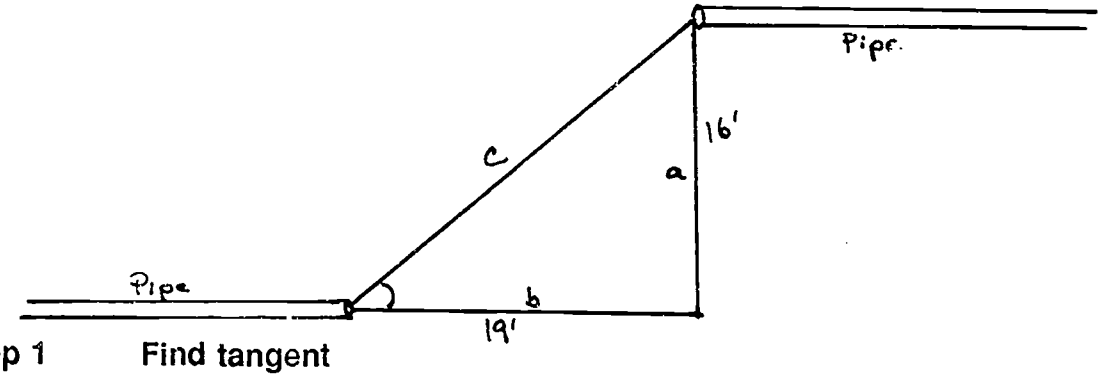
Step 4 Find the cut length of the connecting pipe

The formula for cut length is: Gap is 1/8"

Cut length	=	**Run**	-	**2 Take outs**	**- 2 Gaps**
Cut length	=	_____"	-	2(_____)	- 2(.125)
Cut length	=	_____"	-	_____"	-.25"
Cut length	=	_____"			

#2 answer: 37 11/16" or 3'1 11/16"

3. You are connecting two 14" pipes. You measure the distances between the two pipes and find side a = 16' and side b = 19'. What angle do the elbows need to be and what is the size of the cut length of pipe to connect these pipes?



Step 1 Find tangent

tangent = $\frac{\text{opposite}}{\text{adjacent}}$ = $\frac{\_\_\_\_}{\_\_\_\_}$ = .____ = _____°

Use the Tan chart on the page 7 to find the Tan .

Step 2 Find Offset (hypotenuse)

To find the length of the offset (in math this is called the hypothenuse of the triangle) use your calculator with the formula below and change to inches (1" = 12"):

a^2	+	b^2	=	c^2
_____	+	_____	=	c
_____	+	_____	=	c
_____			=	c

Step 3 Find Take Out

The take out formula for a 14" pipe is: radius of 14" pipe is __"

Take out	=	**tan $\frac{\_\_\_\_^\circ}{2}$**	**x**	**radius**
Take out	=	tan _____°	x	__"
Take out	=	_____	x	__"
Take out	=	_____"		

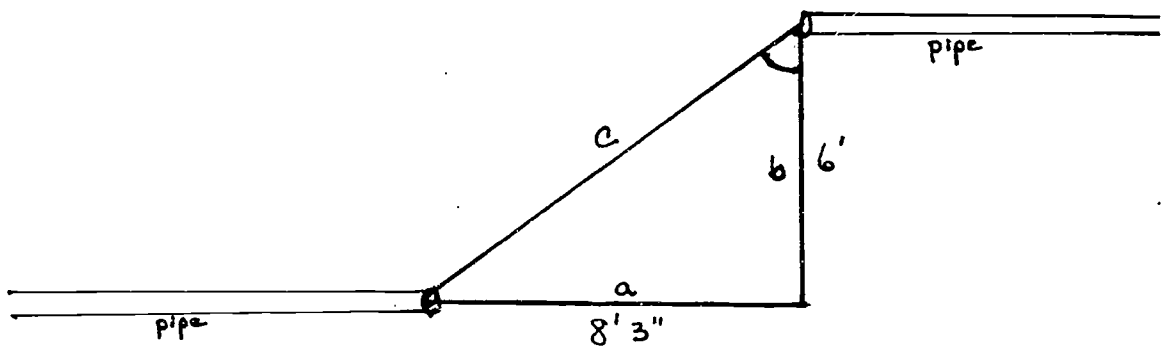
Step 4 Find the cut length of the connecting pipe

The formula for cut length is: Gap is 1/8"

Cut length	=	**Run**	-	**2 Take outs**	**- 2 Gaps**
Cut length	=	_____"	-	2(_____)	- 2(.125)
Cut length	=	_____"	-	_____"	-.25"
Cut length	=	_____"			

#3 answers: 40°; 23' 6 5/8"

4. You are connecting two 10" pipes. You measure the distances between the two pipes and find side a = 8'3" and side b = 6'. What angle do the elbows need to be and what is the size of the cut length of pipe to connect these pipes?



Step 1 Find tangent

tangent = $\frac{\text{opposite}}{\text{adjacent}}$ = _____ = _____ = _____°

Step 2 Find Offset (hypotenuse)

To find the length of the offset (in math this is called the hypothenuse of the triangle) use your calculator with the formula below and change to inches (1" = 12"):

a^2	+	b^2	=	c^2
_____	+	_____	=	c
_____	+	_____	=	c
_____			=	c

Step 3 Find Take Out

The take out formula for a 10" pipe is: radius of 10" pipe is __"

Take out = tan $\frac{\_\_\_\_°}{2}$ x radius

Take out = tan _____° x __"

Take out = _____ x __"

Take out = _____"

Step 4 Find the cut length of the connecting pipe

The formula for cut length is: Gap is 1/8"

Cut length	=	**Run**	-	**2 Take outs**	**- 2 Gaps**
Cut length	=	_____"	-	2(_____)	- 2(.125)
Cut length	=	_____"	-	_____"	-.25"
Cut length	=	_____"			

#4 answers: 54° and 8'10 15/16"

5. You are connecting two 2" pipes. You measure the distances between the two pipes and find side a = 4'8" and side b = 7'5". What angle do the elbows need to be and what is the size of the cut length of pipe to connect these pipes?

Step 1 Find tangent

$$\text{tangent} = \frac{\text{opposite}}{\text{adjacent}} = \frac{\_\_\_\_\_}{\_\_\_\_\_} = .\_\_\_\_\_ = \_\_\_\_\_^\circ$$

Step 2 Find Offset (hypotenuse)

To find the length of the offset (in math this is called the hypotenuse of the triangle) use your calculator with the formula below and change to inches (1" = 12"):

a^2	+	b^2	=	c^2
_____	+	_____	=	c
_____	+	_____	=	c
_____			=	c

Step 3 Find Take Out

The take out formula for a 2" pipe is: radius of 2" pipe is __"

Take out	**=**	**tan $\frac{\_\_\_\_°}{2}$**	**x**	**radius**
Take out	=	tan _____°	x	__"
Take out	=	_____	x	__"
Take out	=	_____"		

Step 4 Find the cut length of the connecting pipe

The formula for cut length is: Gap is 1/8"

Cut length	**=**	**Run**	**-**	**2 Take outs**	**- 2 Gaps**
Cut length	=	_____"	-	2(_____)	- 2(.125)
Cut length	=	_____"	-	_____"	-.25"
Cut length	=	_____"			

#5 answers: 32° and 8' 7 1/4"